

Introduction to LArSoft

Erica Snider
Fermilab

LArSoft core support team:

Vito di Benedetto, Lynn Garren
Patrick Gartung, Gianluca Petrillo,
Saba Sehrish, Erica Snider

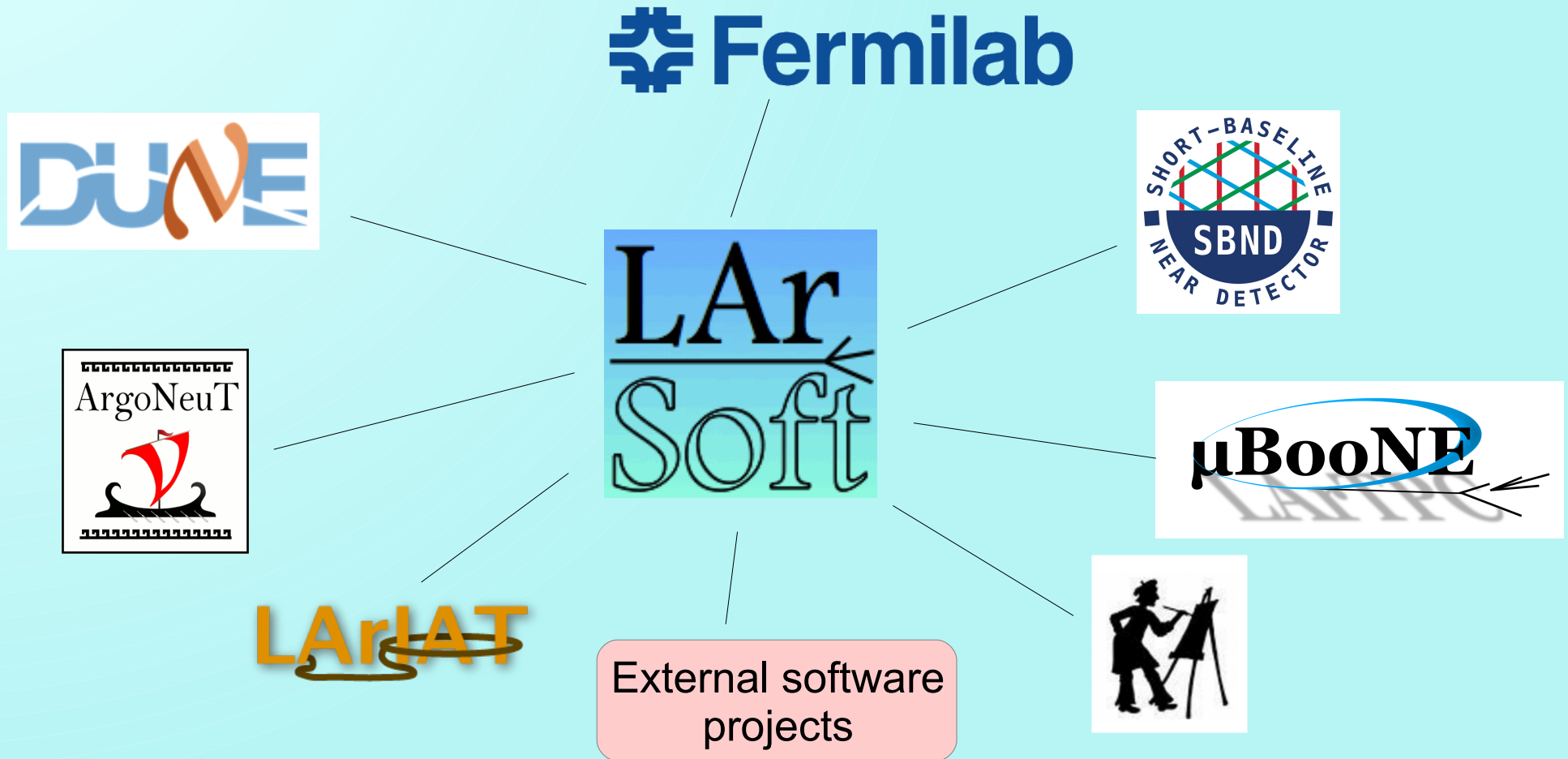
Young DUNE
September 16, 2016
Fermilab

Outline

- What is LArSoft?
- Operation of single-phase LAr TPC
- Reconstruction / data structure overview
 - Special algorithm notes
 - Additional reconstruction considerations
- Simulation overview
- LArSoft design principles
- Using LArSoft
- Resources

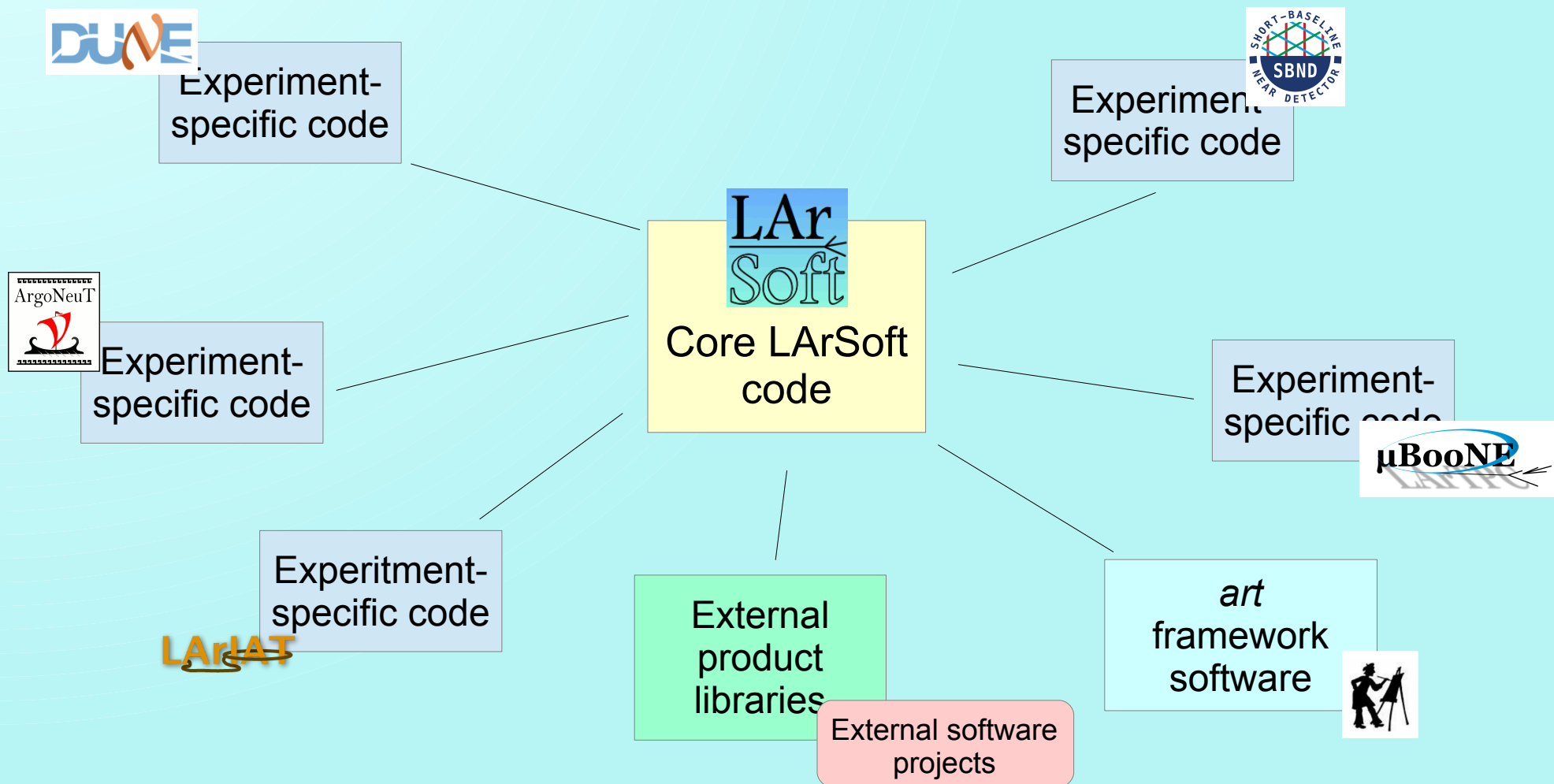
The slides today were updated from the 2015 art / LArSoft Course content.
 See the [course indico page](#) for more information, material on LArSoft

What is LArSoft?: (1) **A collaboration** of experiments,
Fermilab, other stakeholders



To provide integrated, experiment-independent software tools for LAr TPC neutrino experiments to perform simulation, reconstruction analysis.

What is LArSoft?: (2) **A body of code** that interfaces with experiment-specific, *art* framework and external product software

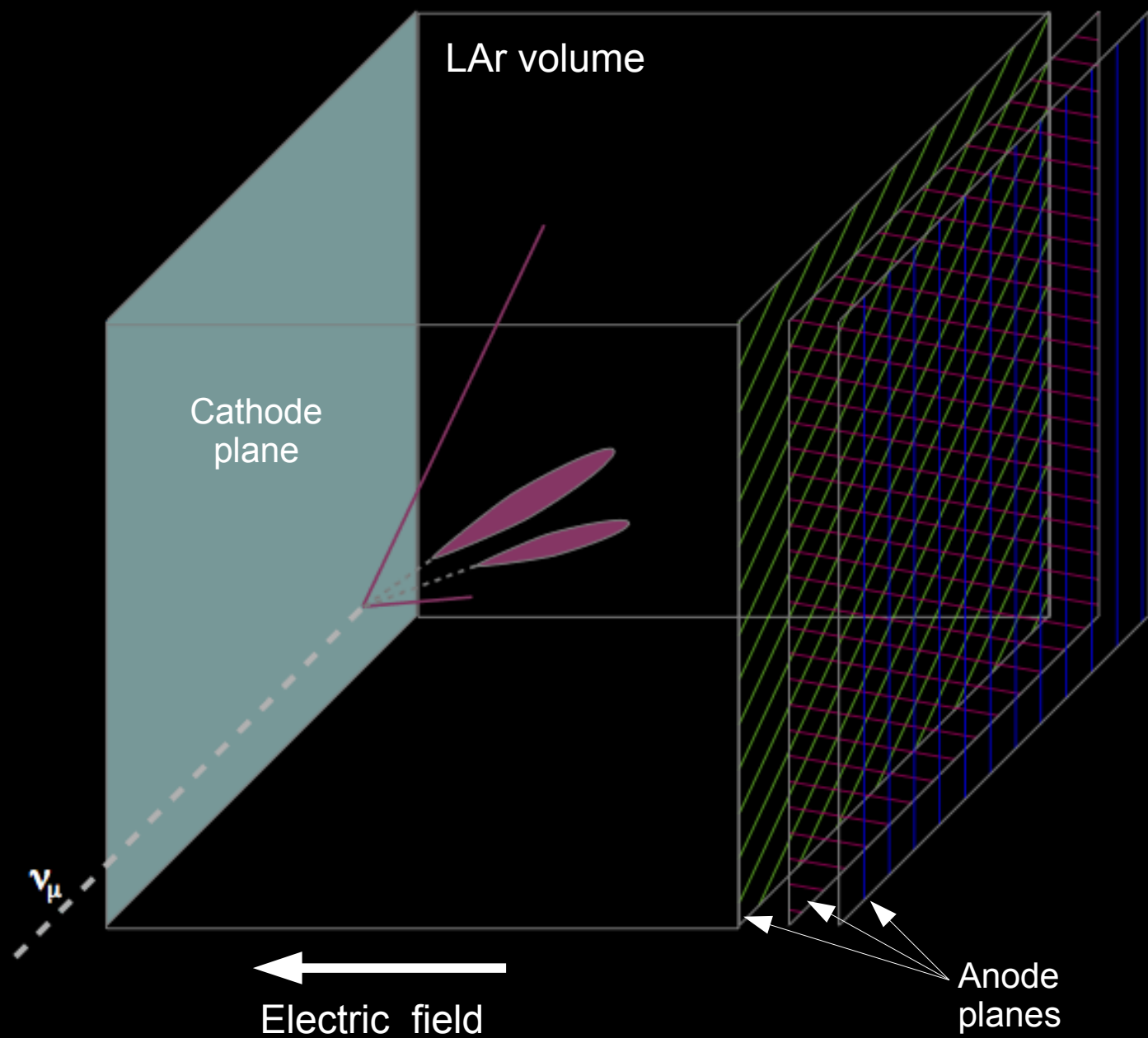


Experiments contribute common
“core” LArSoft code

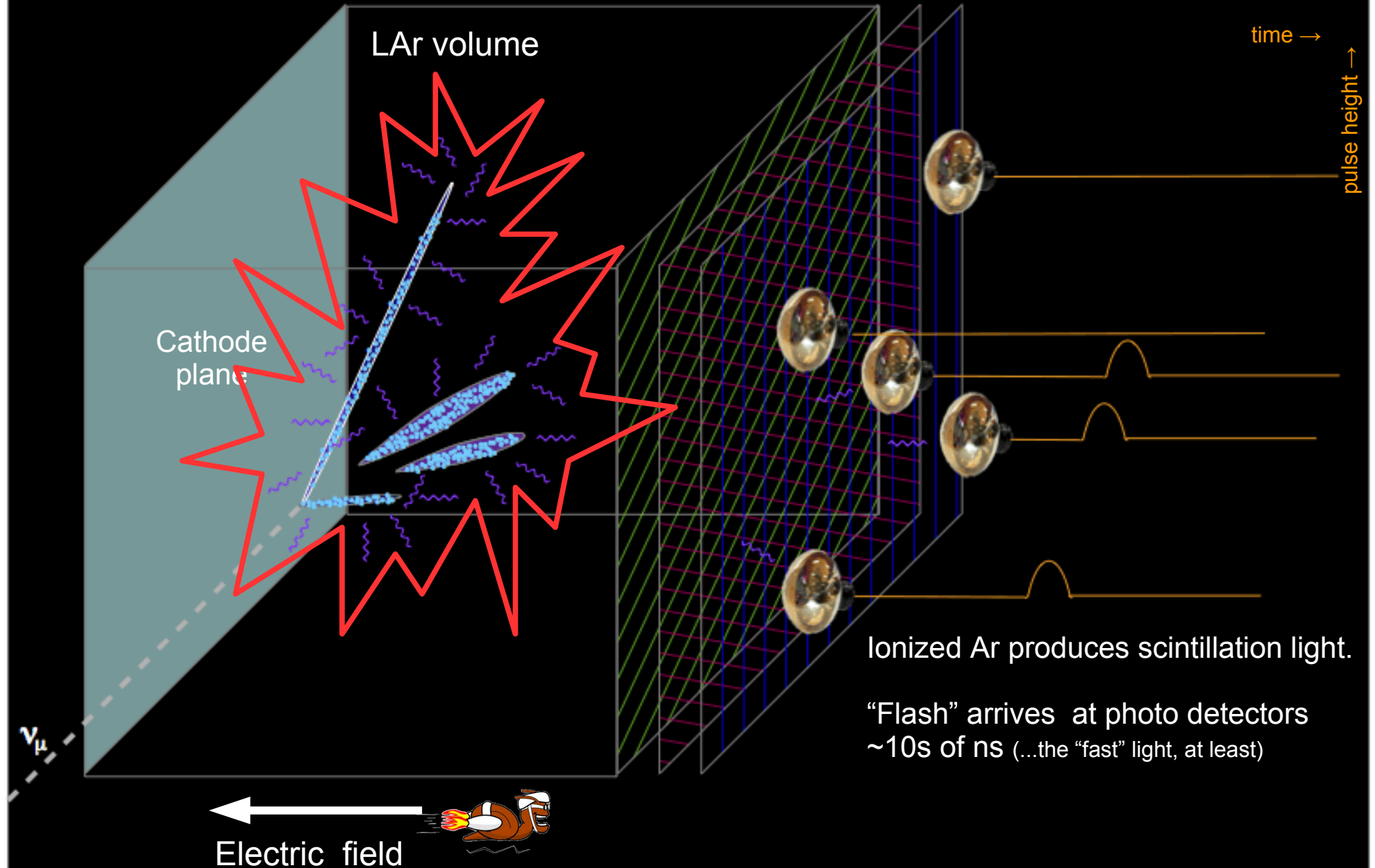
230k lines of C++ in core LArSoft
450k+ lines including expt code

Operation of a single-phase LAr TPC

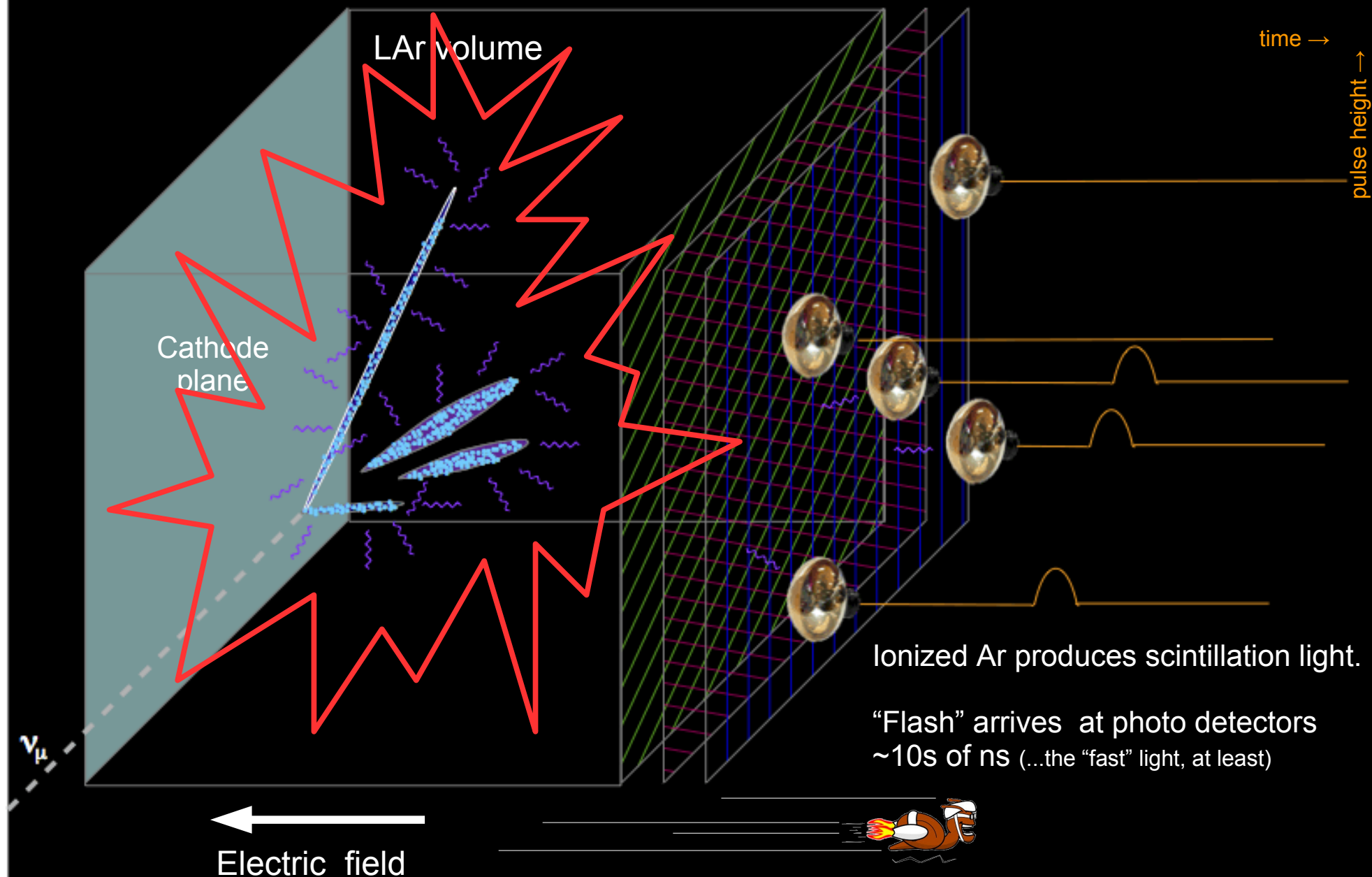
Operation of single-phase LAr TPC



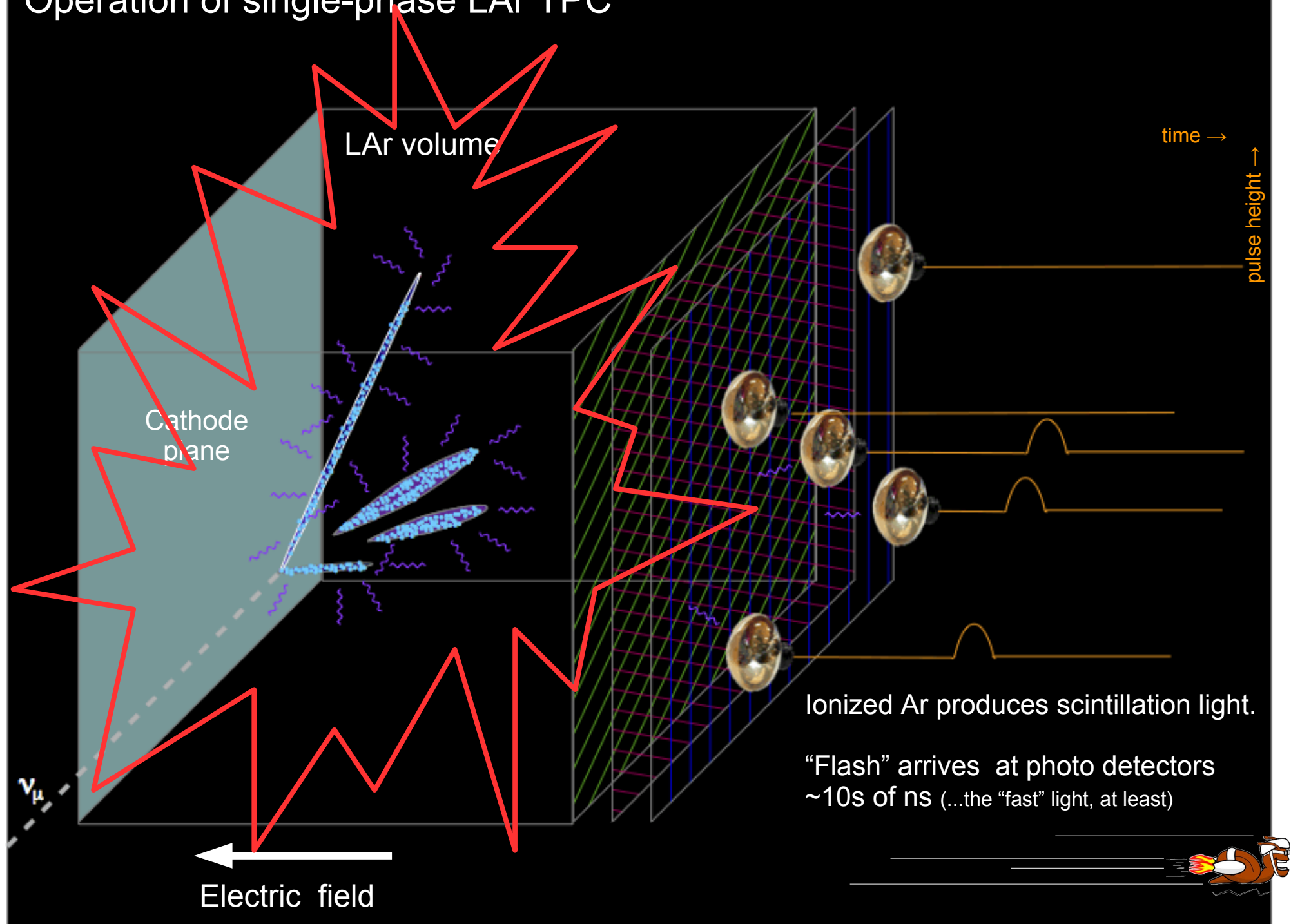
Operation of single-phase LAr TPC



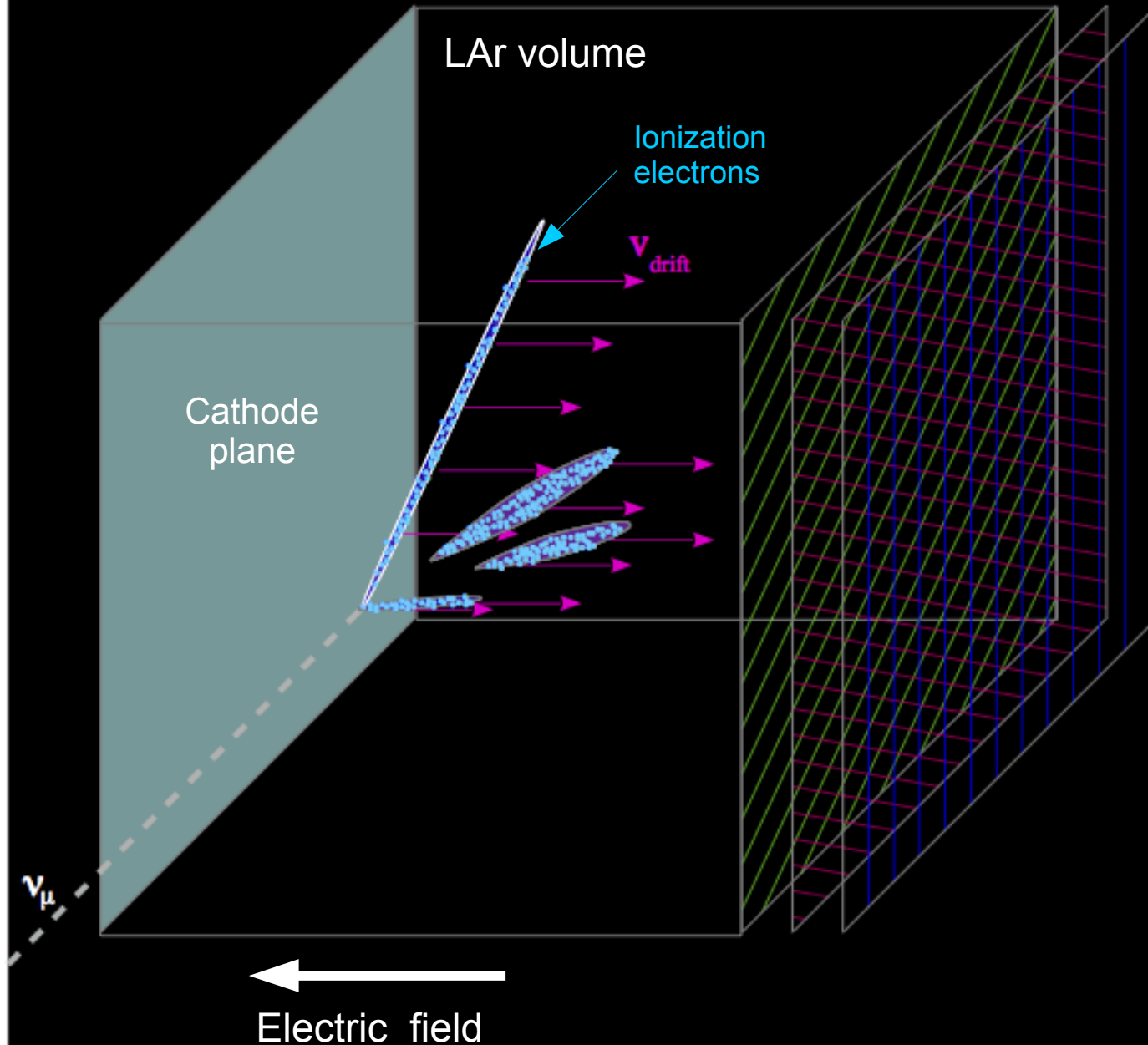
Operation of single-phase LAr TPC



Operation of single-phase LAr TPC



Operation of single-phase LAr TPC



Neutrino interacts with
Ar nucleus

Charged secondaries
ionize the Ar

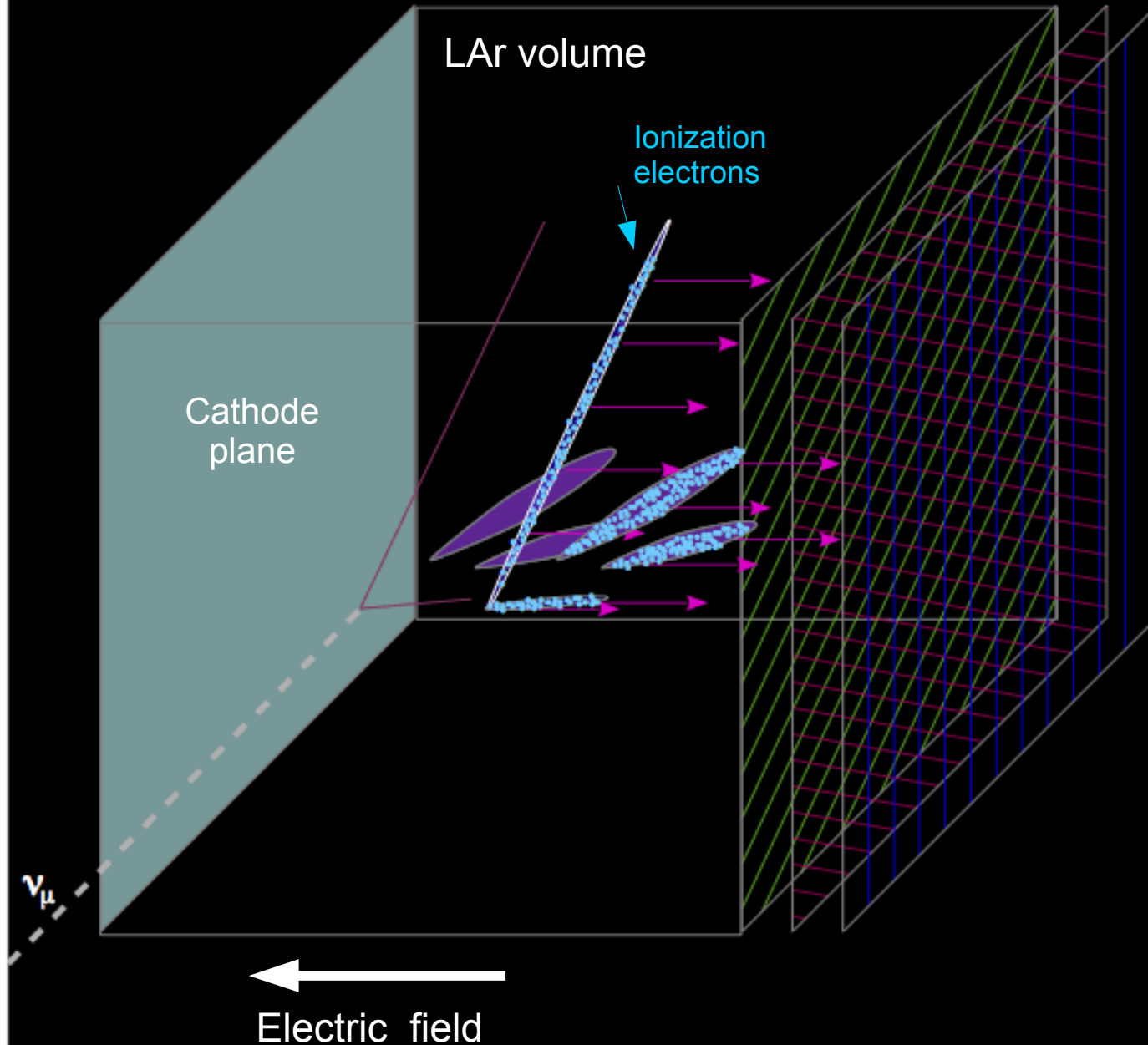
Electrons drift in the
electric field toward
anode wires

$$v_{\text{drift}} \approx 1 - \text{few mm}/\mu\text{s}$$



Max drift time \sim ms!!

Operation of single-phase LAr TPC



Neutrino interacts with
Ar nucleus

Charged secondaries
ionize the Ar

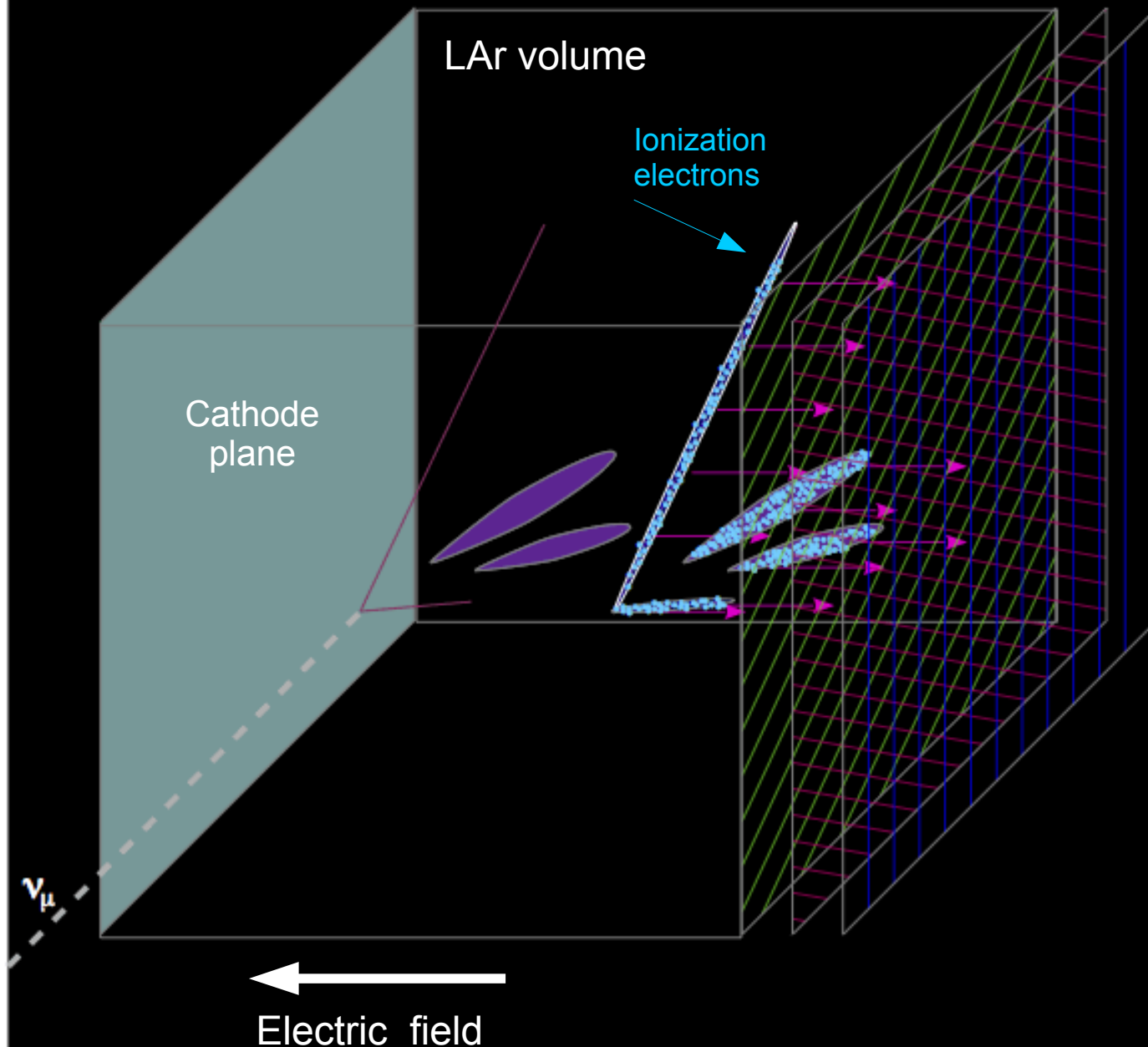
Electrons drift in the
electric field toward
anode wires

$$v_{\text{drift}} \approx 1 - \text{few mm}/\mu\text{s}$$



Max drift time \sim ms!!

Operation of single-phase LAr TPC



Neutrino interacts with
Ar nucleus

Charged secondaries
ionize the Ar

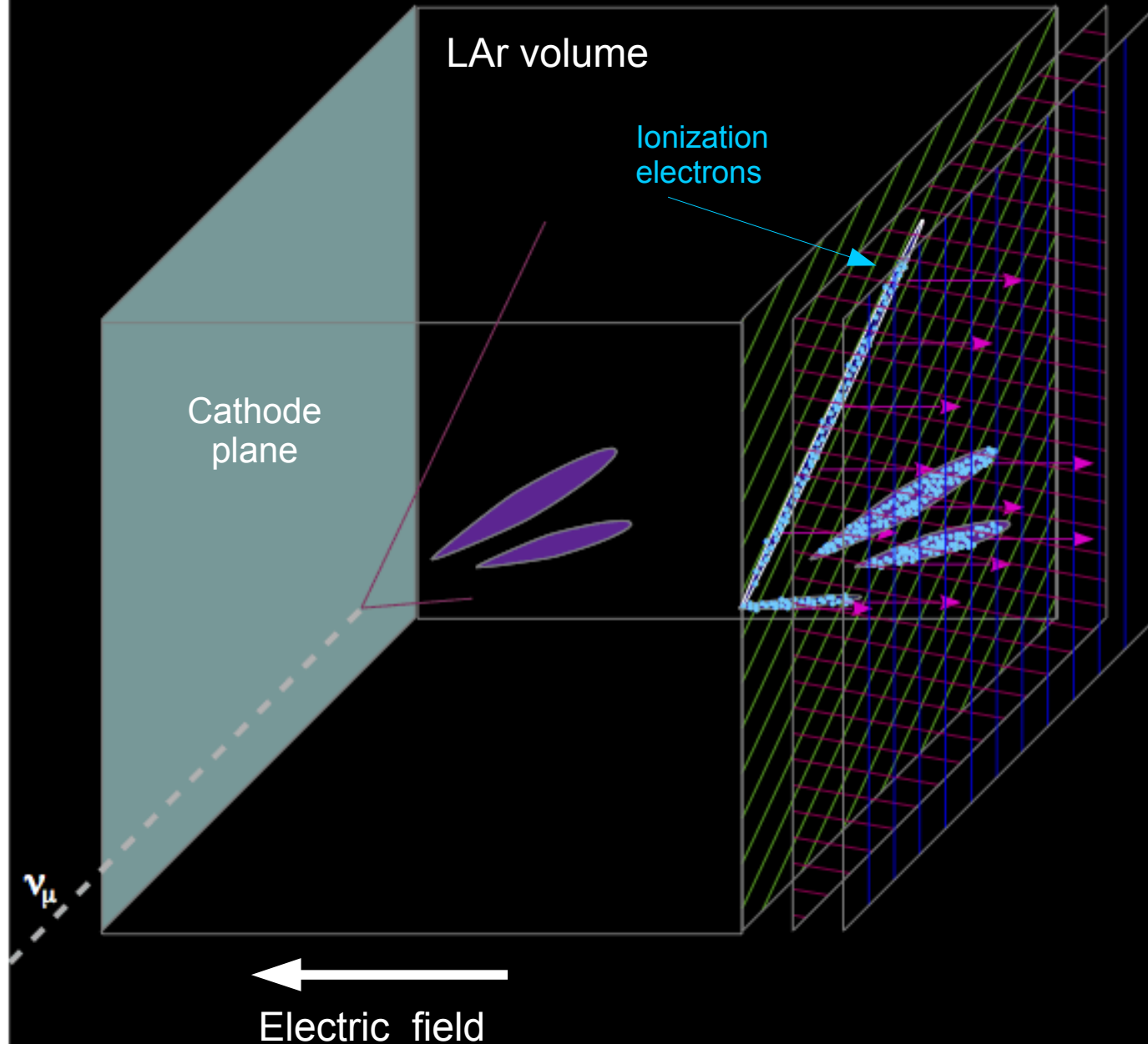
Electrons drift in the
electric field toward
anode wires

$$v_{\text{drift}} \approx 1 - \text{few mm}/\mu\text{s}$$



Max drift time \sim ms!!

Operation of single-phase LAr TPC



Neutrino interacts with
Ar nucleus

Charged secondaries
ionize the Ar

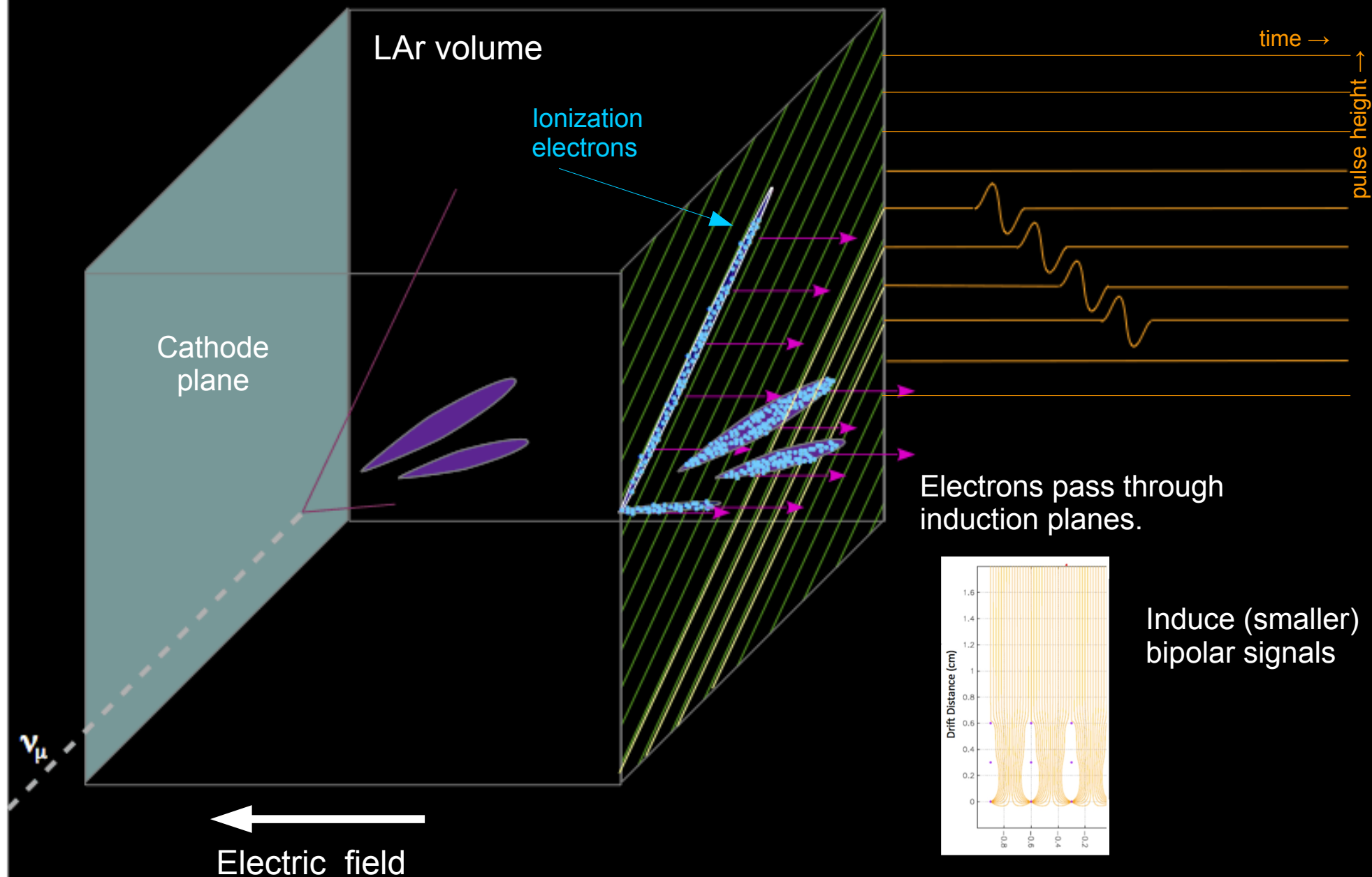
Electrons drift in the
electric field toward
anode wires

$$v_{\text{drift}} \approx 1 - \text{few mm}/\mu\text{s}$$

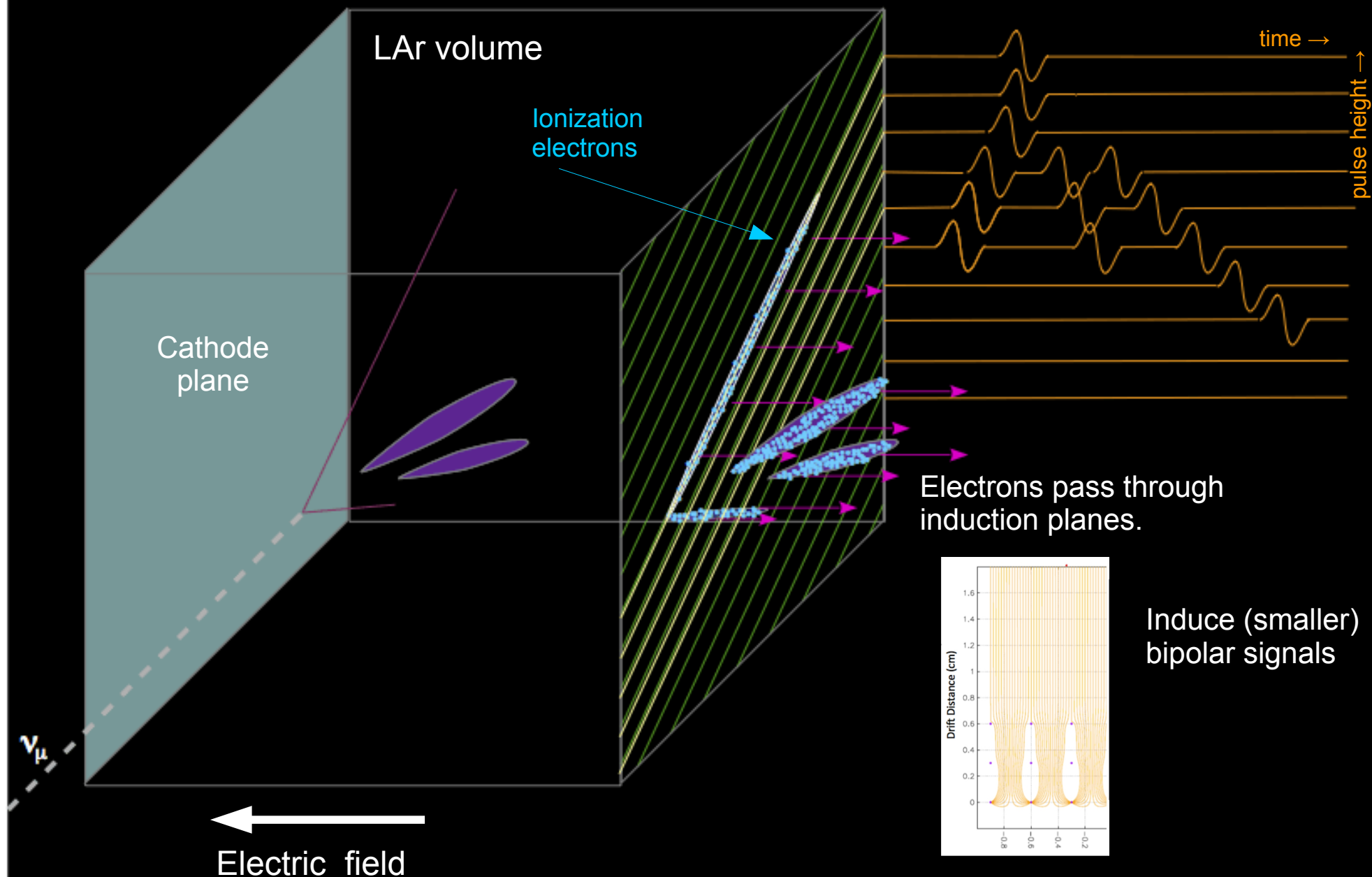


Max drift time \sim ms!!

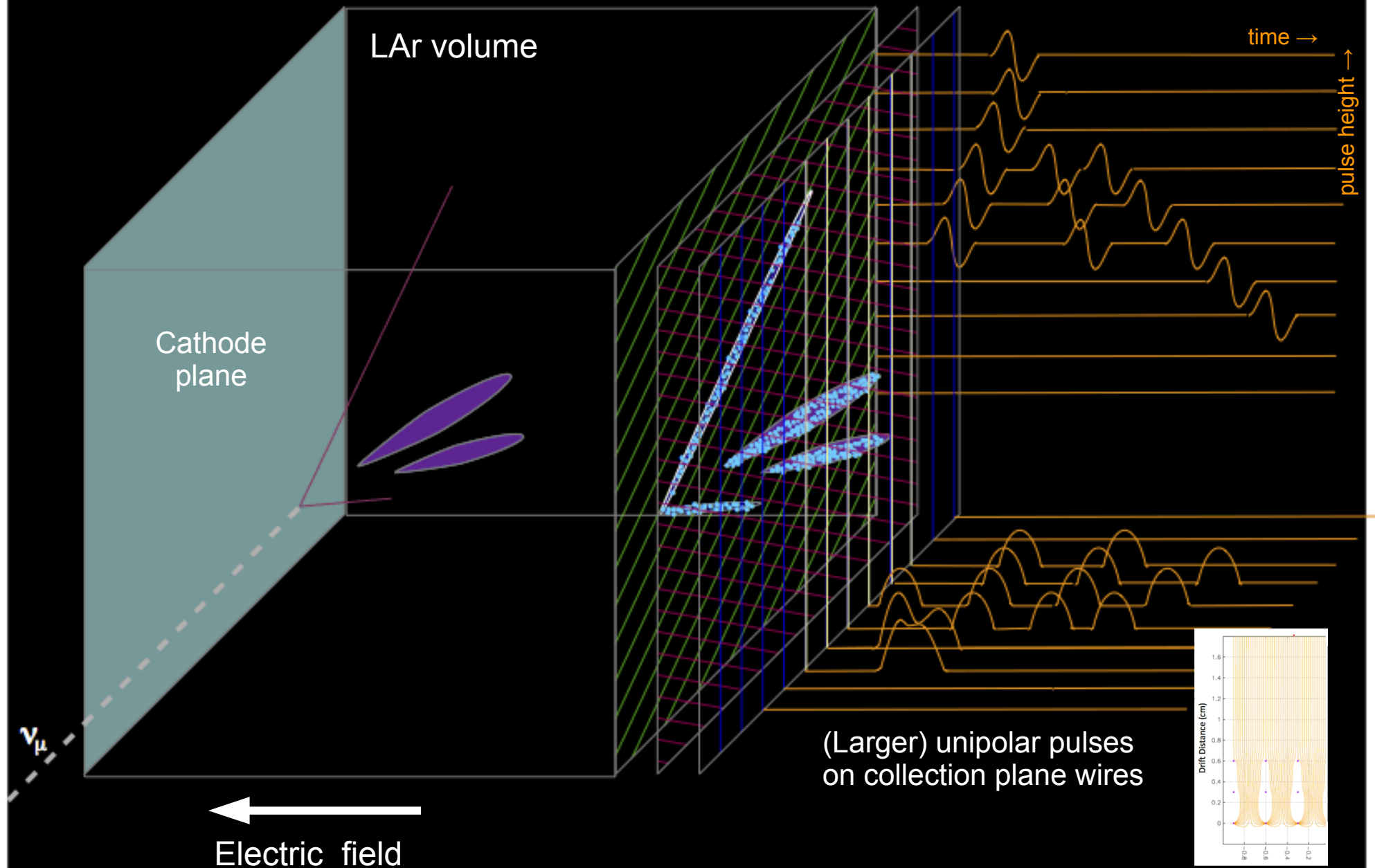
Operation of single-phase LAr TPC



Operation of single-phase LAr TPC



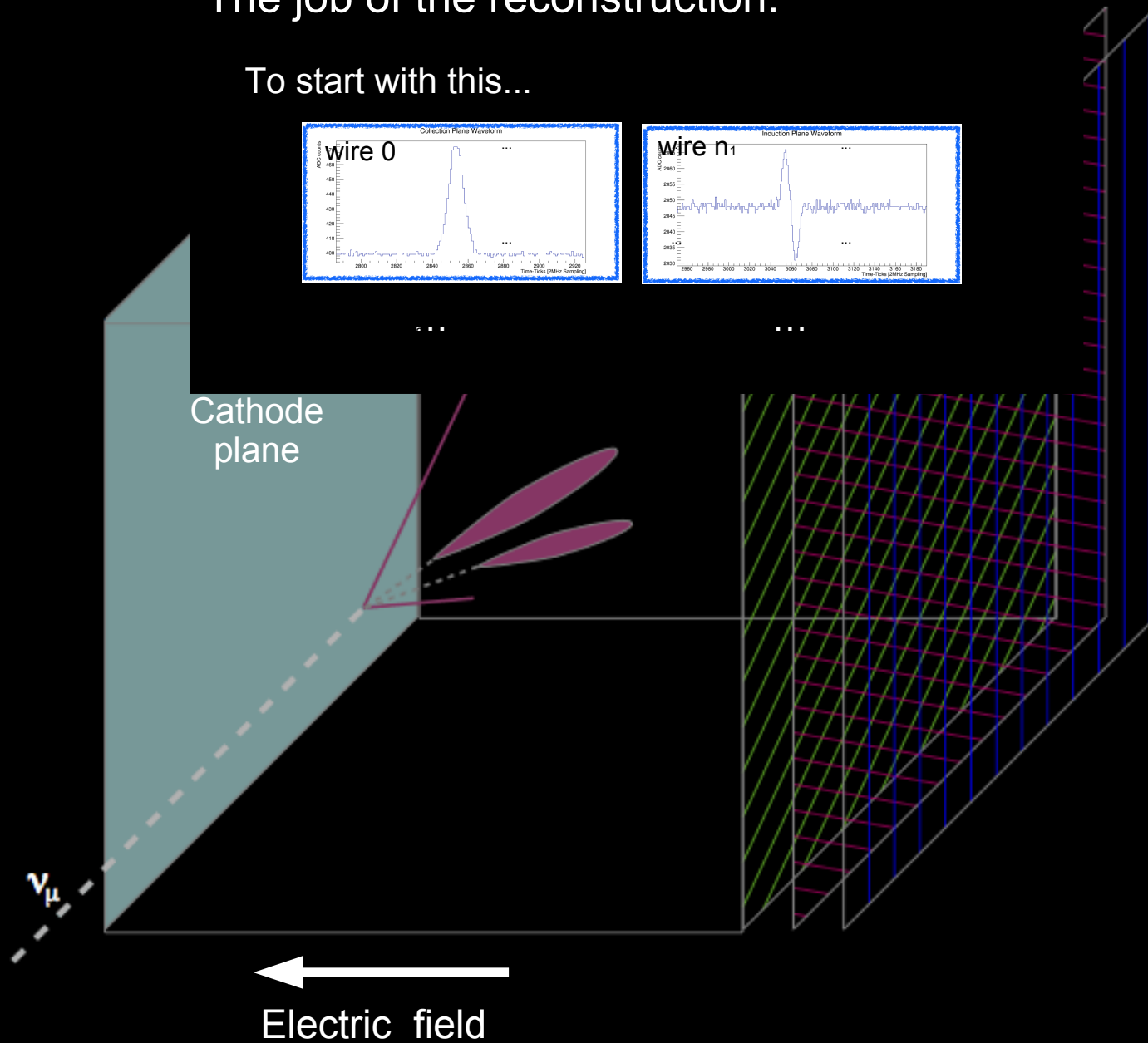
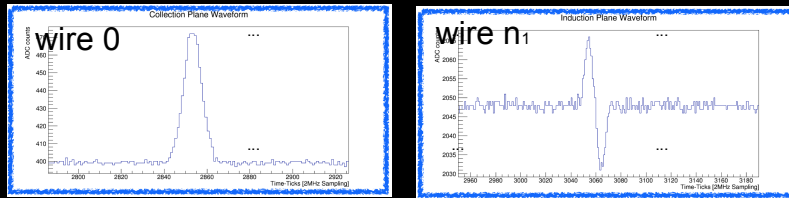
Operation of single-phase LAr TPC



Operation of single-phase LAr TPC

The job of the reconstruction:

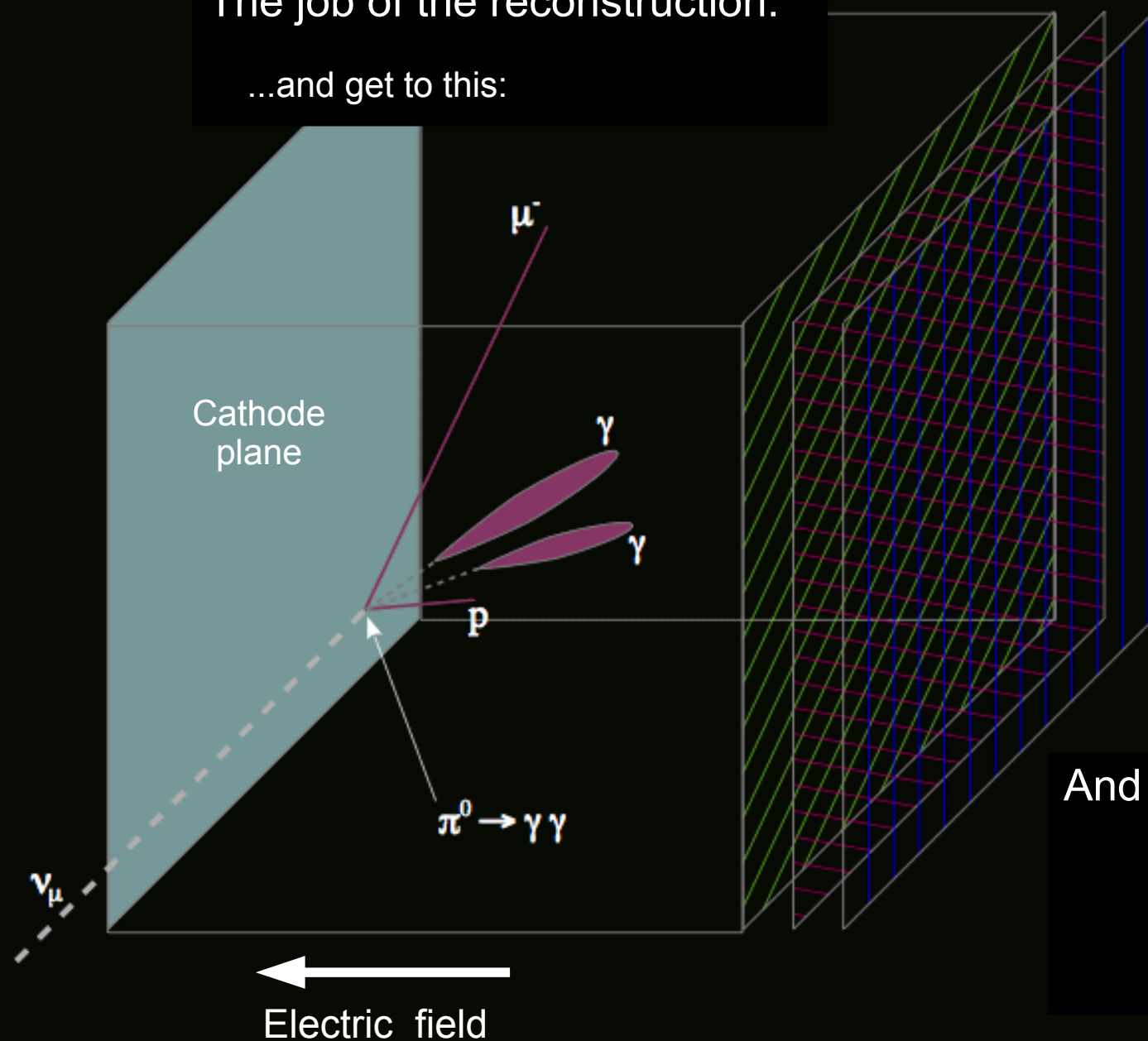
To start with this...



Operation of single-phase LAr TPC

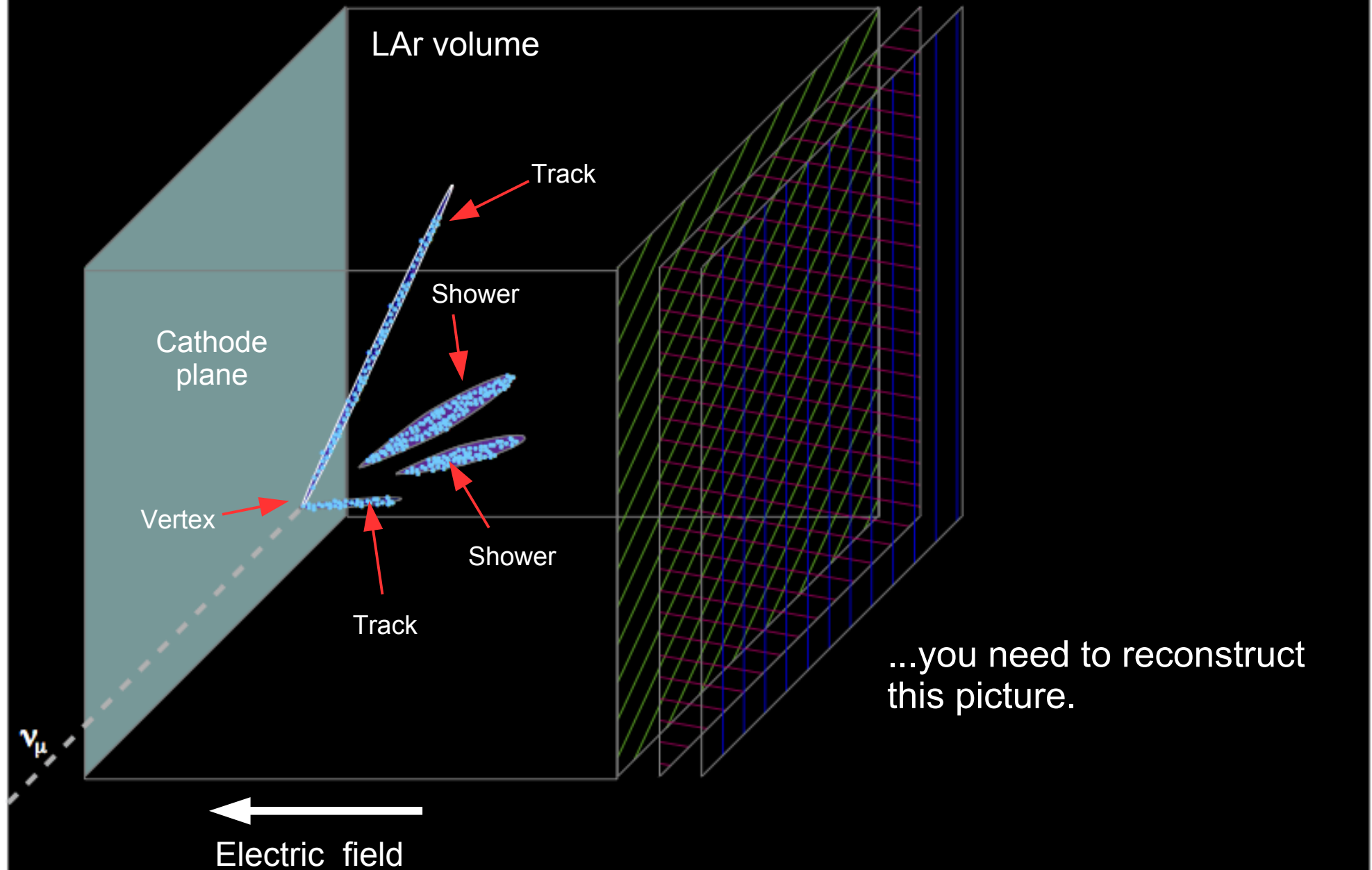
The job of the reconstruction:

...and get to this:

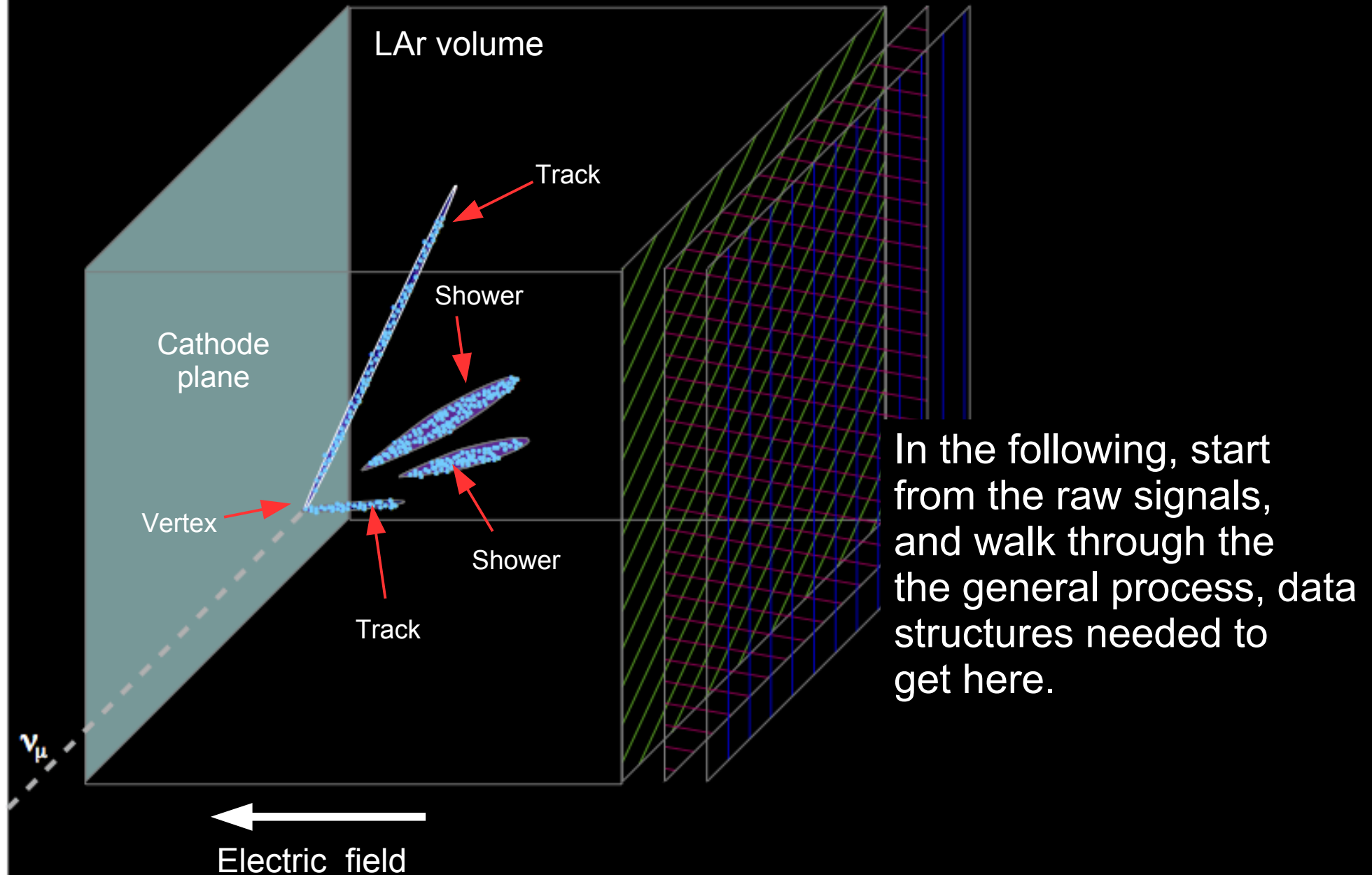


And to get here...

Operation of single-phase LAr TPC



Operation of single-phase LAr TPC



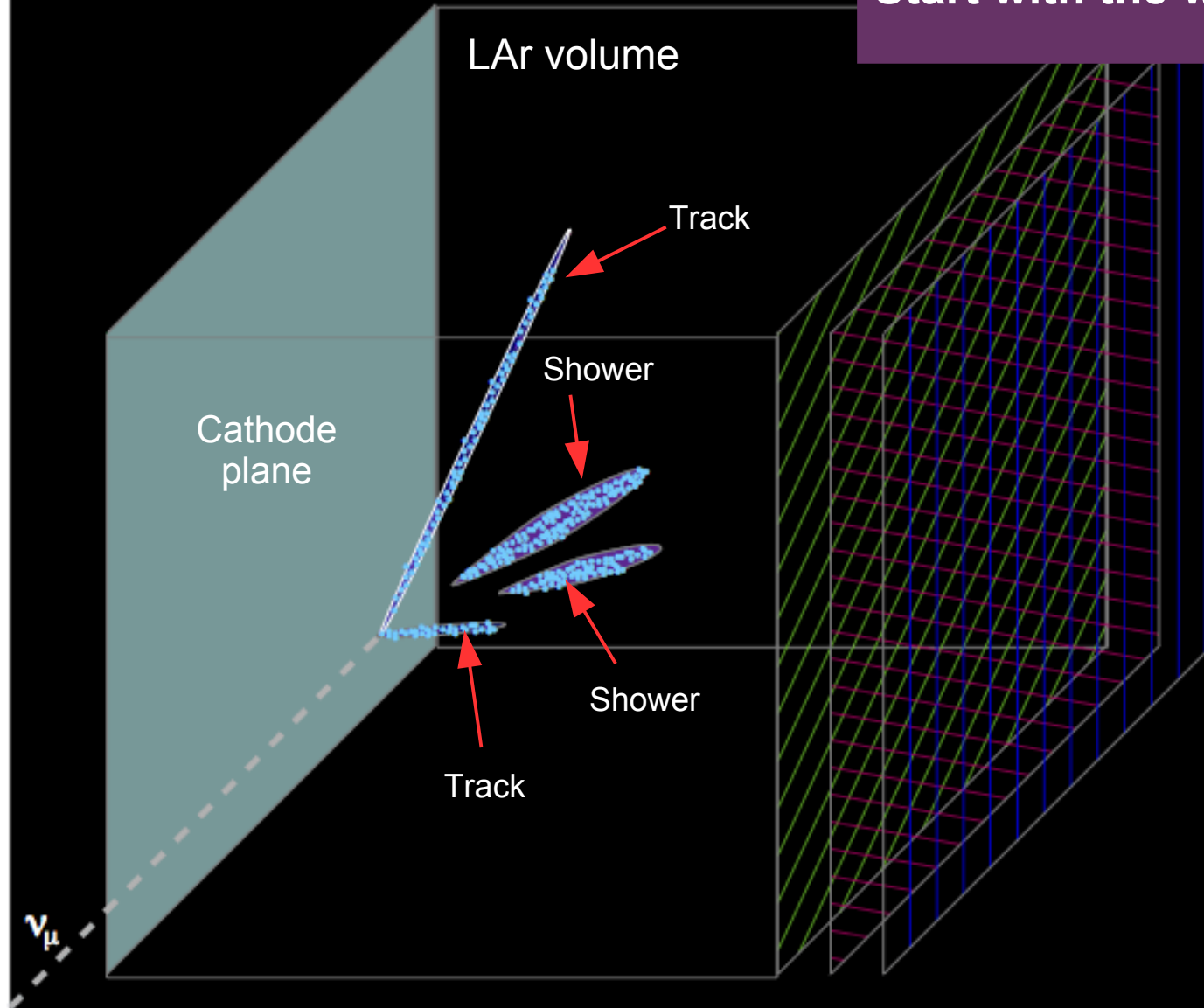
Reconstruction workflow and data structure overview

Comments on reconstruction workflow

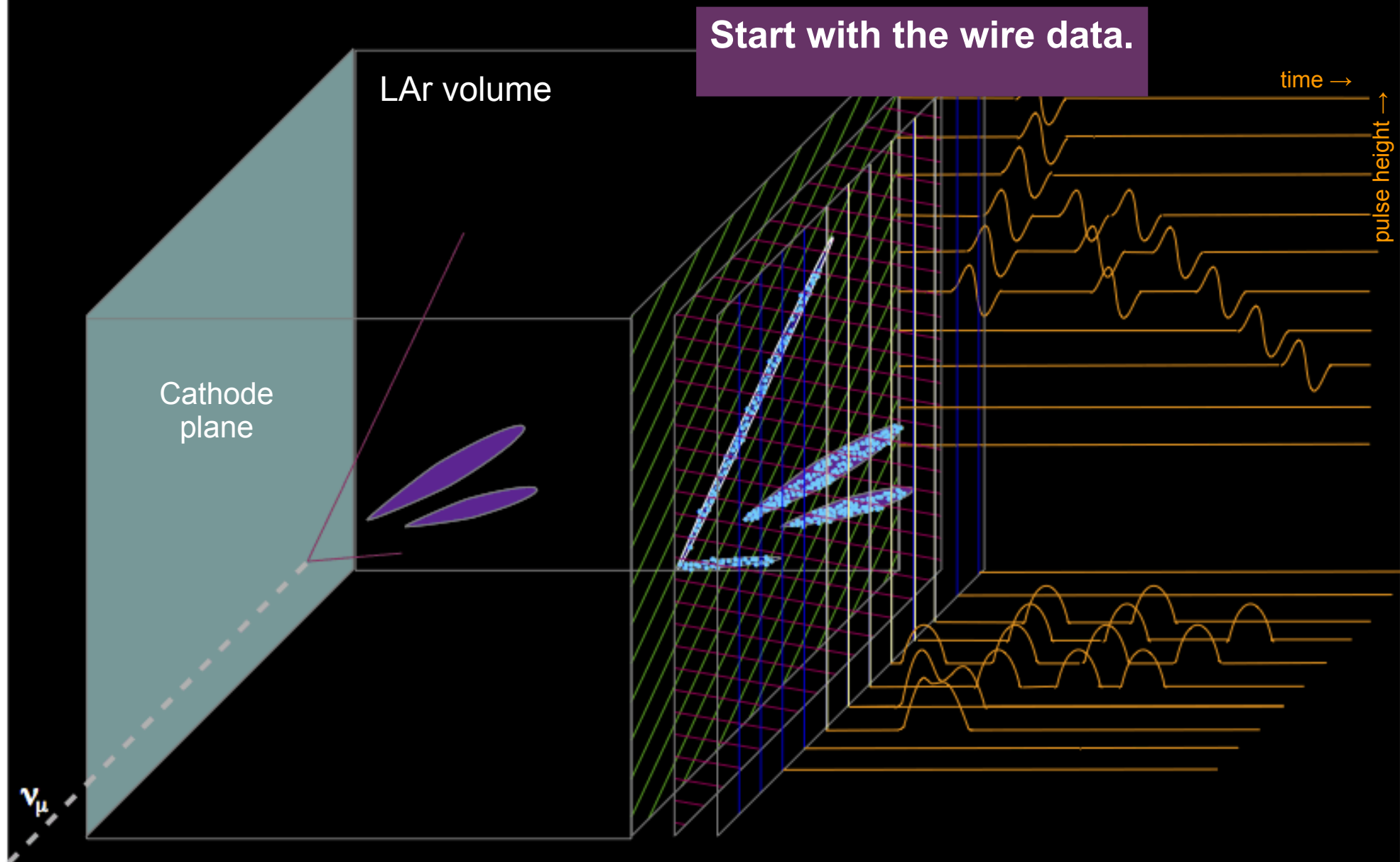
- What follows is a simple, highly idealized representation of the typical reconstruction workflow
- In practice, the reconstruction
 - is highly iterative
 - has multiple parallel algorithm workflow
 - has multiple steps interleavedas increasingly complex structures are extracted from the data
- Will come back to talk about this later

Reconstruction workflow and data structures

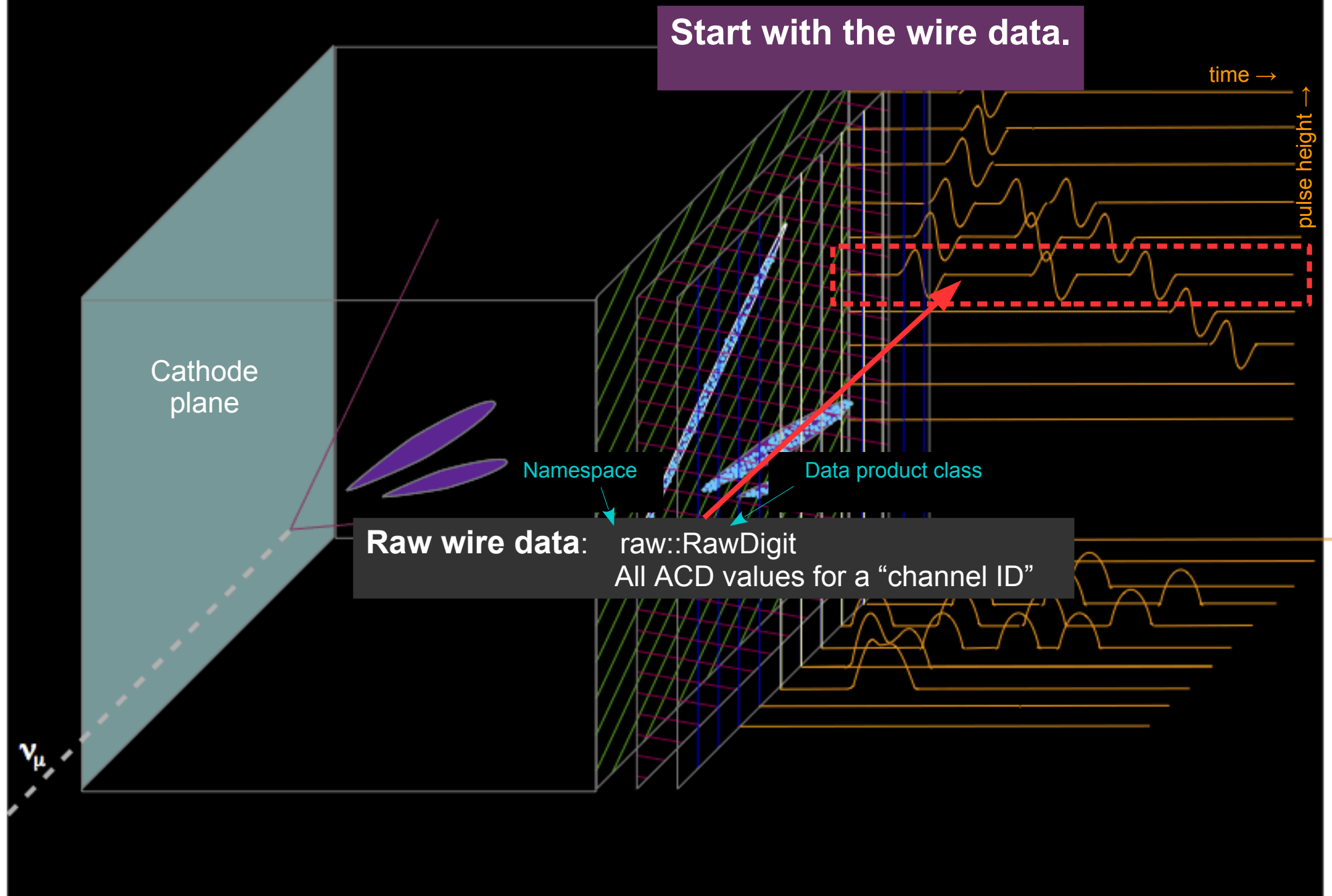
Start with the wire data.



Reconstruction workflow and data structures



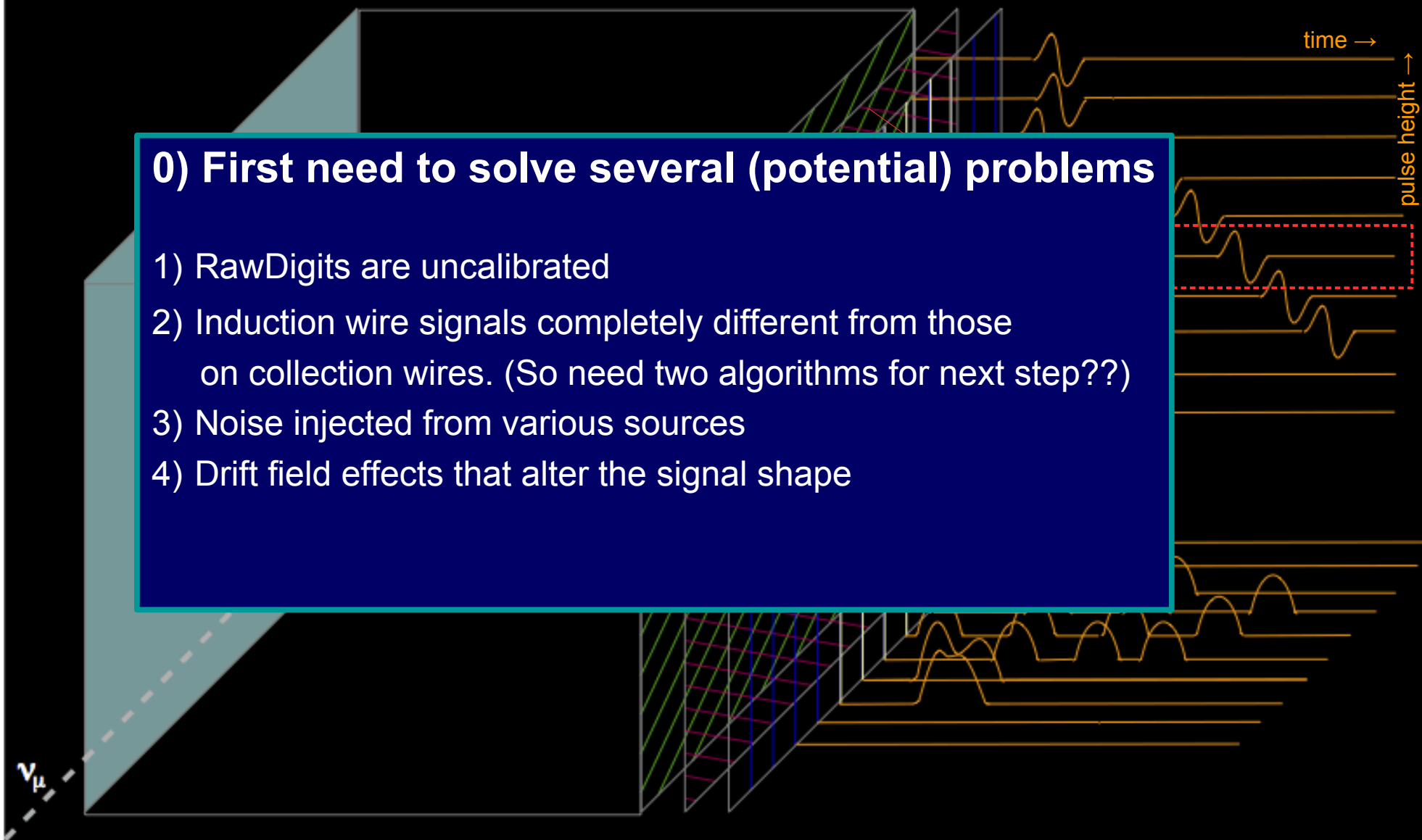
Reconstruction workflow and data structures



Reconstruction workflow and data structures

0) First need to solve several (potential) problems

- 1) RawDigits are uncalibrated
- 2) Induction wire signals completely different from those on collection wires. (So need two algorithms for next step??)
- 3) Noise injected from various sources
- 4) Drift field effects that alter the signal shape



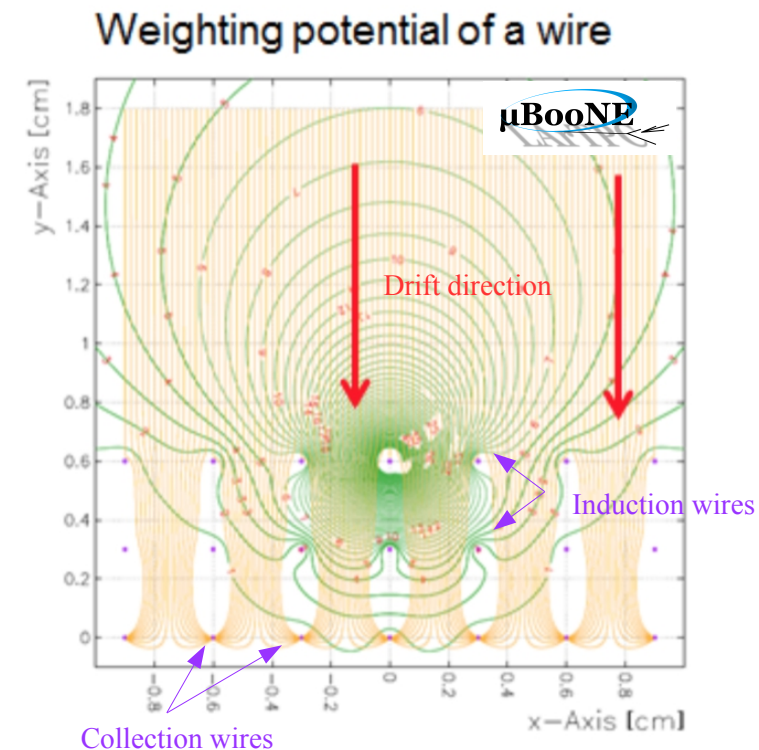
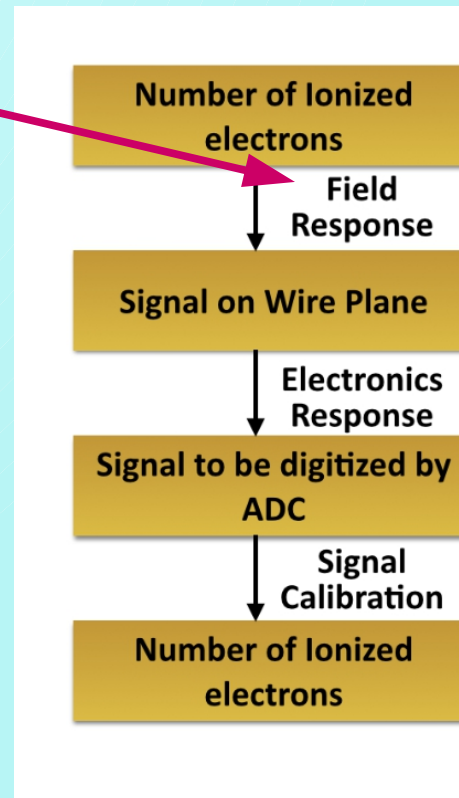
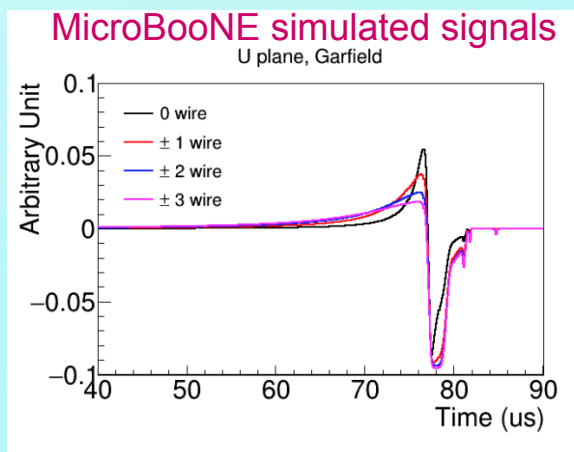
(0) Signal processing and calibration

- Want to recover charge vs time on a wire
 - The level of detail may depend on the task
 - E.g., calorimetry may require more fidelity than pattern recognition
- Consider MicroBooNE example: fairly simple workflow at present
 - Calibration: baseline subtraction
 - Noise removal
 - Deconvolution
 - Removes effects of electronics response, field response

TPC signal formation

Induced current $i \propto q \vec{E}_w \cdot \vec{v}_q$
 \vec{E}_w = "weighting E field"
 \vec{v}_q = velocity of charge 'q'

In principle, see charge drifting to neighboring wires too

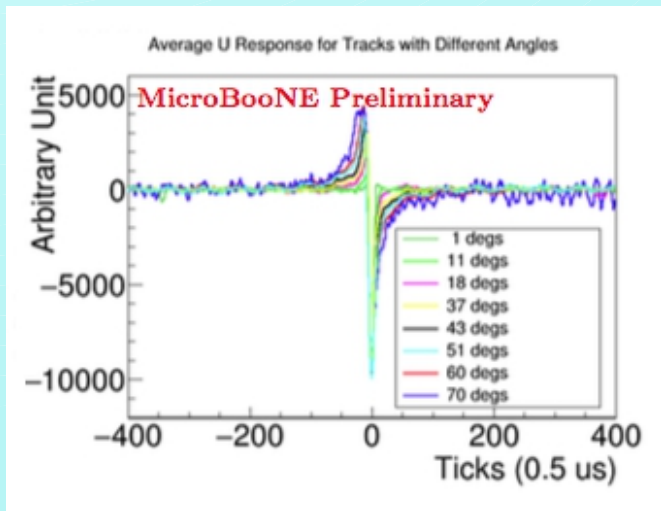


From MicroBooNE-Note-1017-pub

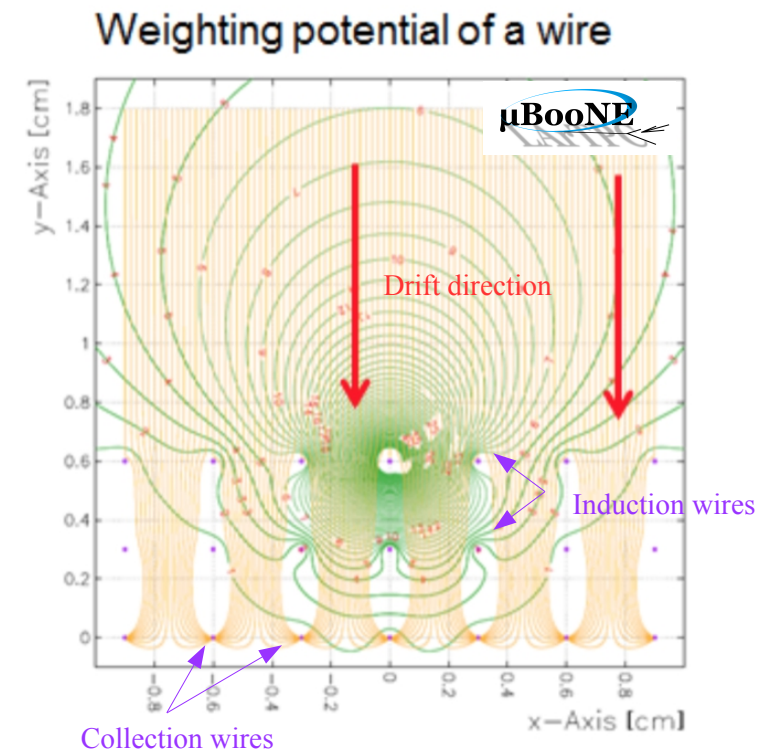
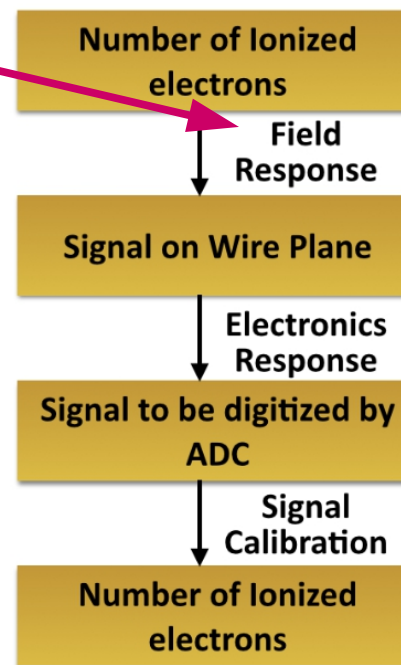
TPC signal formation

Induced current $i \propto q \vec{E}_w \cdot \vec{v}_q$
 \vec{E}_w = "weighting E field"
 \vec{v}_q = velocity of charge 'q'

The signal shape also depends on the track angle



Will come back to this point...



From MicroBooNE-Note-1017-pub

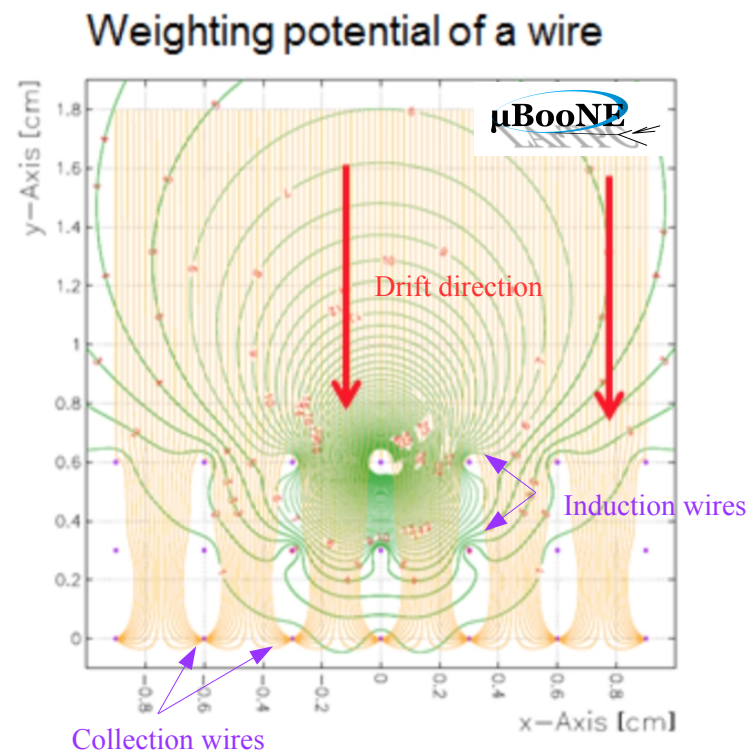
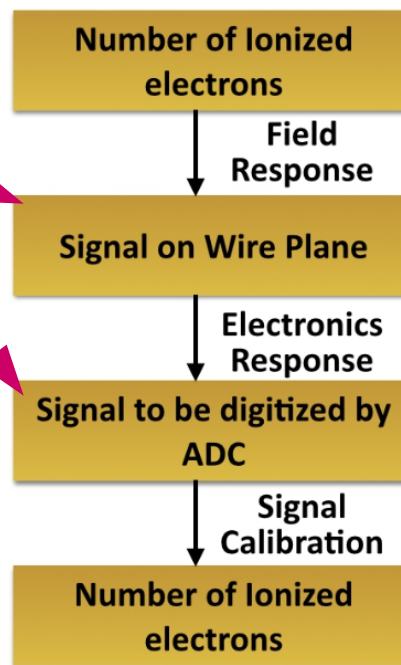
TPC signal formation

Noise injection

MicroBooNE example

Identified sources of noise

- First input transistor
- Warm shaping amplifier (small)
- Other readout circuits (coherent)
- Wire bias power supplies (coherent)
- Cathode HV (coherent)
- ASIC saturation due to wire motion



From MicroBooNE-Note-1017-pub

Treat coherent noise with specialized algorithms

Optimal filter applicable (in principle) to remaining sources during **deconvolution**

Deconvolution

- Given

$$y(t) = (h * x)(t) + n(t)$$

- where $y(t)$ = **measured output signal** (raw digits)

$(h * x)(t)$ = convolution of impulse response $h(t)$ and (unknown) input signal $x(t)$

$n(t)$ = (unknown) noise

- Optimal signal estimate (minimum mean squared error) given only

- Finite **impulse response** of the front-end electronics
- Estimated **mean power spectrum** for the **signal** and the **noise**

(used in a Wiener filter)

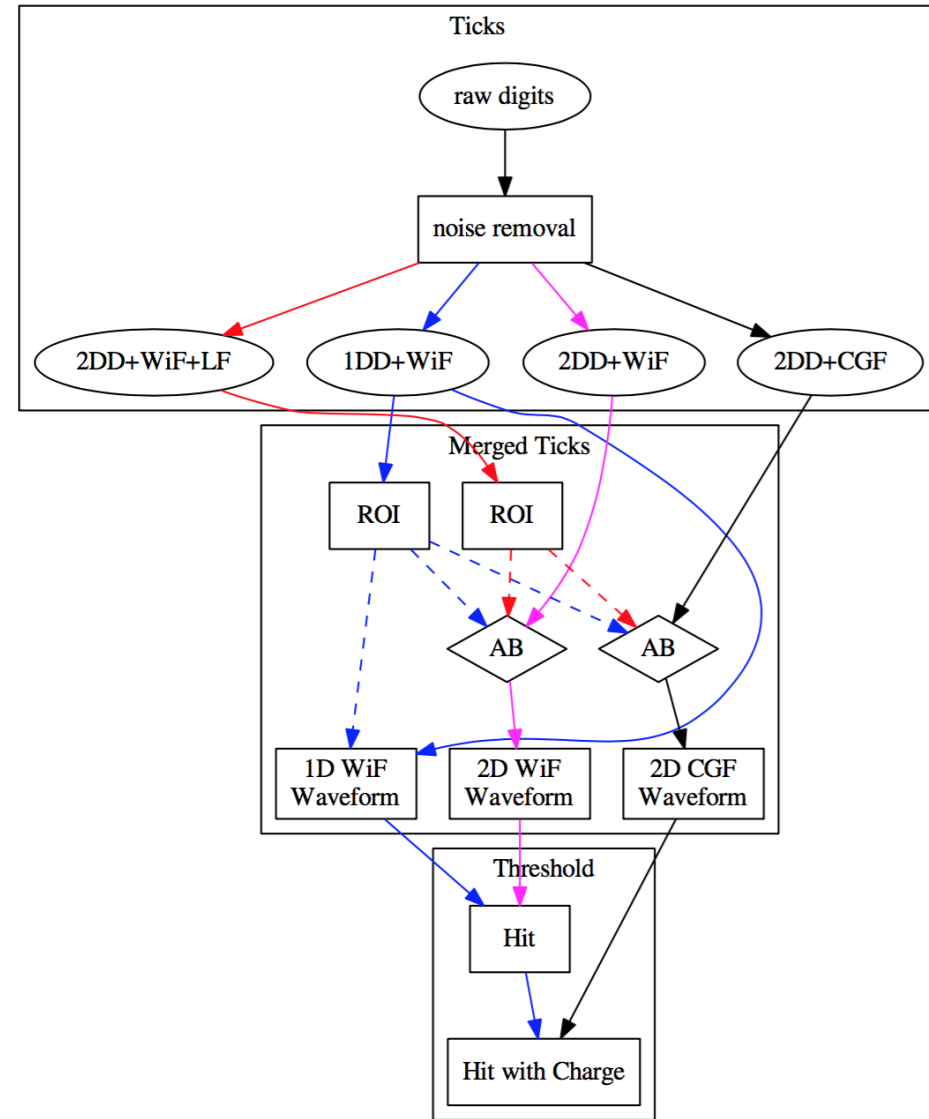
assuming stationary signal and noise power spectra

- But signal spectrum

- depends on track angle
- signals on nearby tracks

In practice, the deconvolution procedure is somewhat complex

An example from MicroBooNE

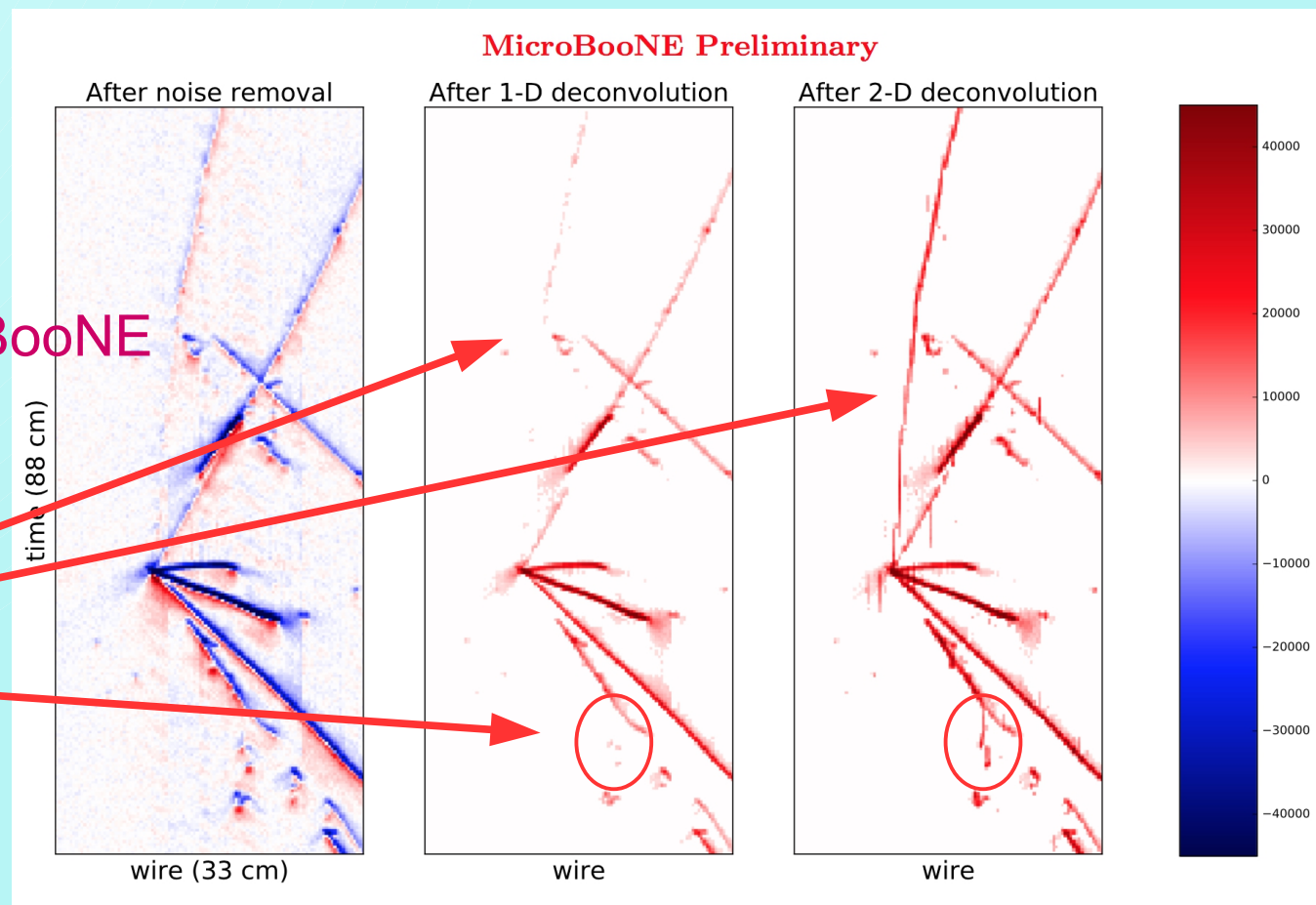


From MicroBooNE-Note-1017-pub

In practice, the deconvolution procedure is somewhat complex

An example from MicroBooNE

It pays to get this right!!



From MicroBooNE-Note-1017-pub

Wire calibration and deconvolution

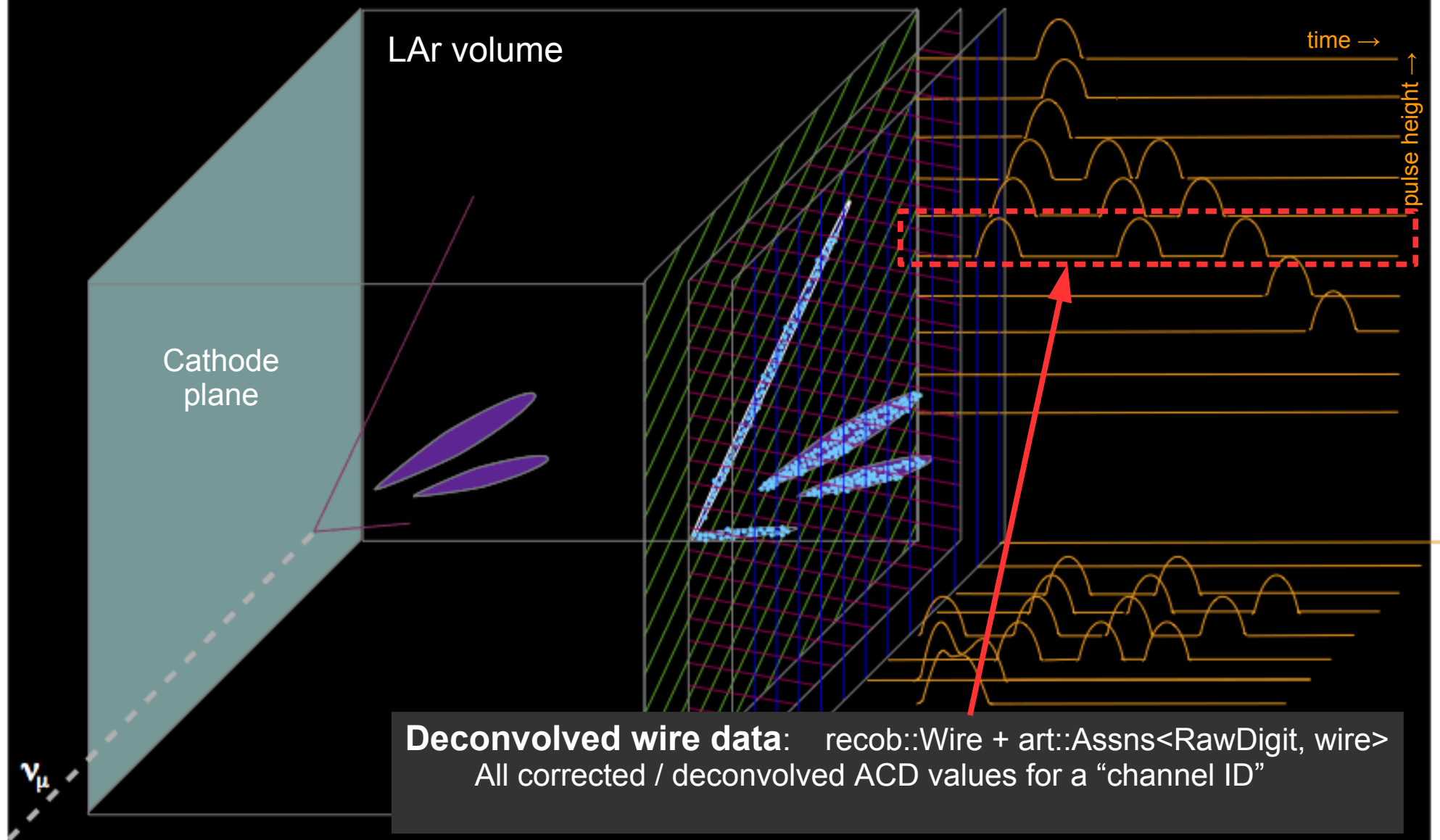
- Calibration
 - Only pedestal subtraction at this phase.
(Channel gains come later...)
- Deconvolution

Performed by a number of classes

CalWire ...	
CalROI ...	
SignalShapingService ...	(1D)
SignalShaping	
LArFFT	
Wire-cell	(2D)

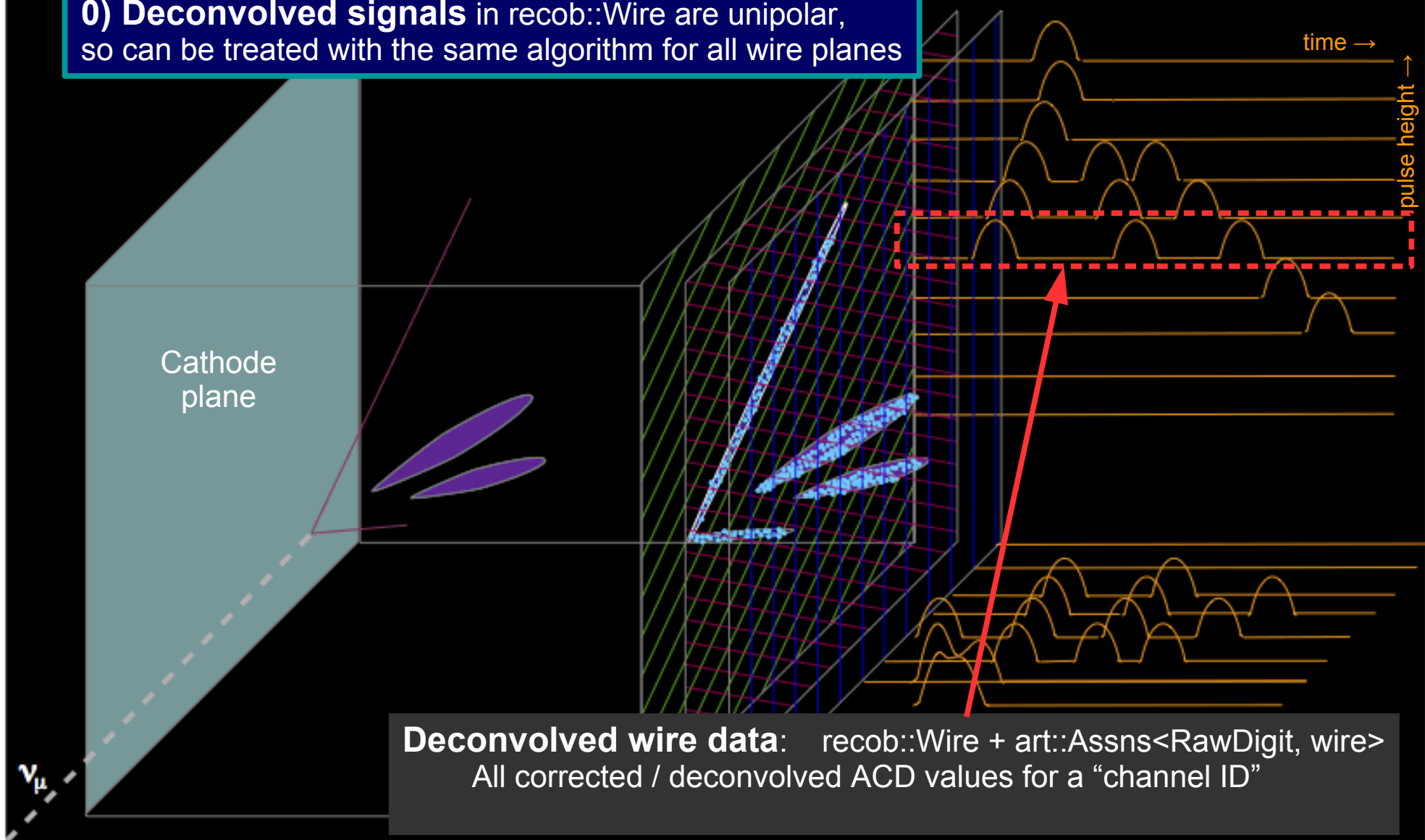
(Experiment-specific)

Reconstruction workflow and data structures



Reconstruction workflow and data structures

0) Deconvolved signals in `recob::Wire` are unipolar, so can be treated with the same algorithm for all wire planes



Reconstruction workflow and data structures

0) Deconvolved signals in `recob::Wire` are unipolar, so can be treated with the same algorithm for all wire planes

Cathode plane

For “ROI” algorithms, keep only the values in “regions of interest” (i.e., zero-supressed)

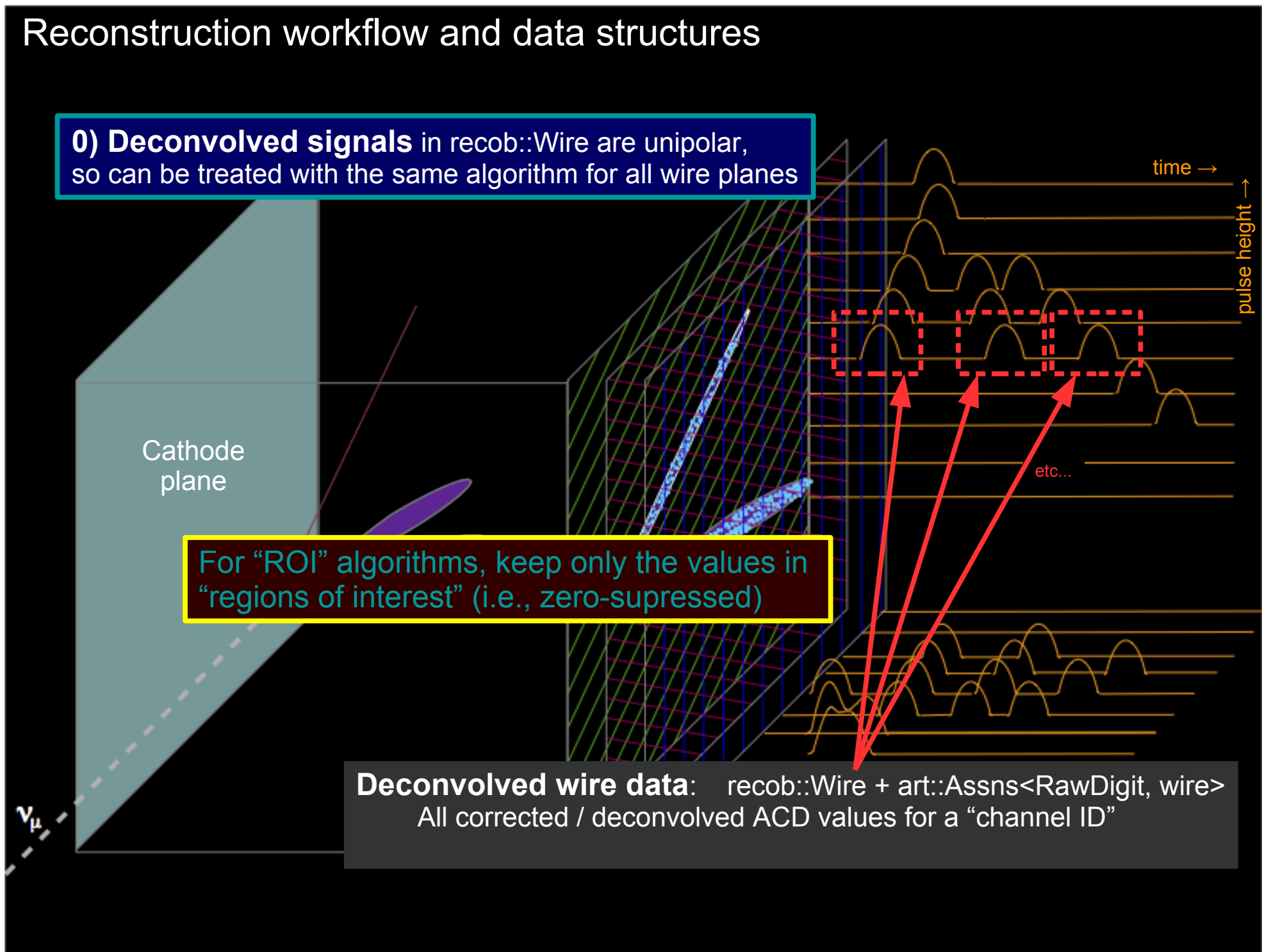
Deconvolved wire data: `recob::Wire + art::Assns<RawDigit, wire>`
All corrected / deconvolved ACD values for a “channel ID”

time →

pulse height →

etc...

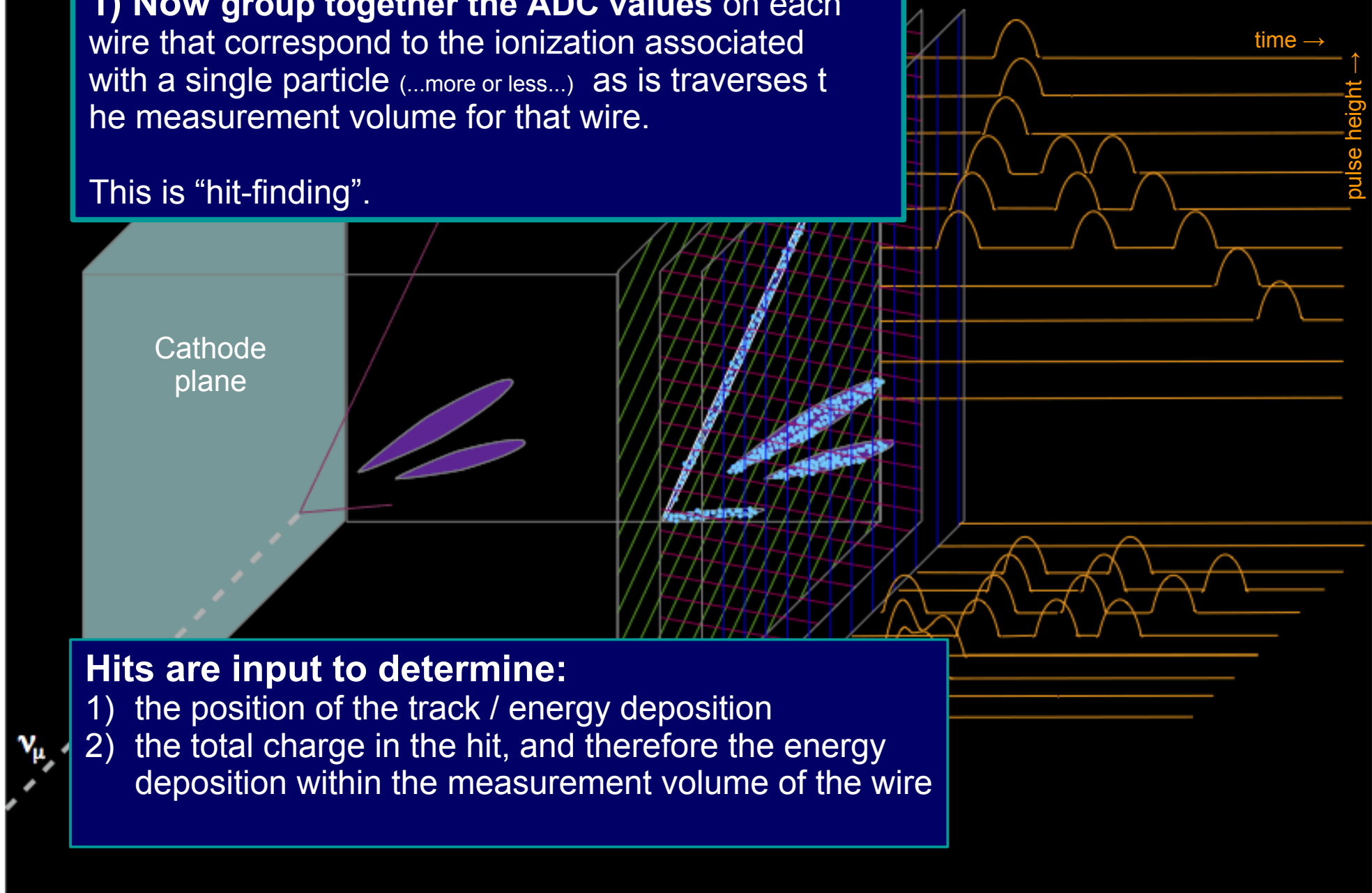
v_{μ}



Reconstruction workflow and data structures

1) Now group together the ADC values on each wire that correspond to the ionization associated with a single particle (...more or less...) as it traverses the measurement volume for that wire.

This is “hit-finding”.



Hits are input to determine:

- 1) the position of the track / energy deposition
- 2) the total charge in the hit, and therefore the energy deposition within the measurement volume of the wire

Reconstruction workflow and data structures

1) Now group together the ADC values on each wire that correspond to the ionization associated with a single particle (...more or less...) as it traverses the measurement volume for that wire.

This is “hit-finding”.

Cathode plane

The output of hit-finding: `recob::Hit + Assns<Wire,Hit>, Assns<RawDigit,Hit>`
All ADC values on a given wire attributed to a single particle, and the arrival time of ionization relative to a common (arbitrary) t_0

Hits are input to determine:

- 1) the position of the track / energy deposition
- 2) the total charge in the hit, and therefore the energy deposition within the measurement volume of the wire

v_μ

time →

pulse height →

Reconstruction workflow and data structures

1) Now group together the ADC values on each wire that correspond to the ionization associated with a single particle (...more or less...) as it traverses the measurement volume for that wire.

This is “hit-finding”.

Cathode plane

The output of hit-finding: `recob::Hit + Assns<Wire,Hit>, Assns<RawDigit,Hit>`
All ADC values on a given wire attributed to a single particle,
and the arrival time of ionization relative to a common (arbitrary) t_0

Hit-finding performed by:

CCHitFinder
GausHitFinder
RawHitFinder
...

← Mainly use this at present

time →

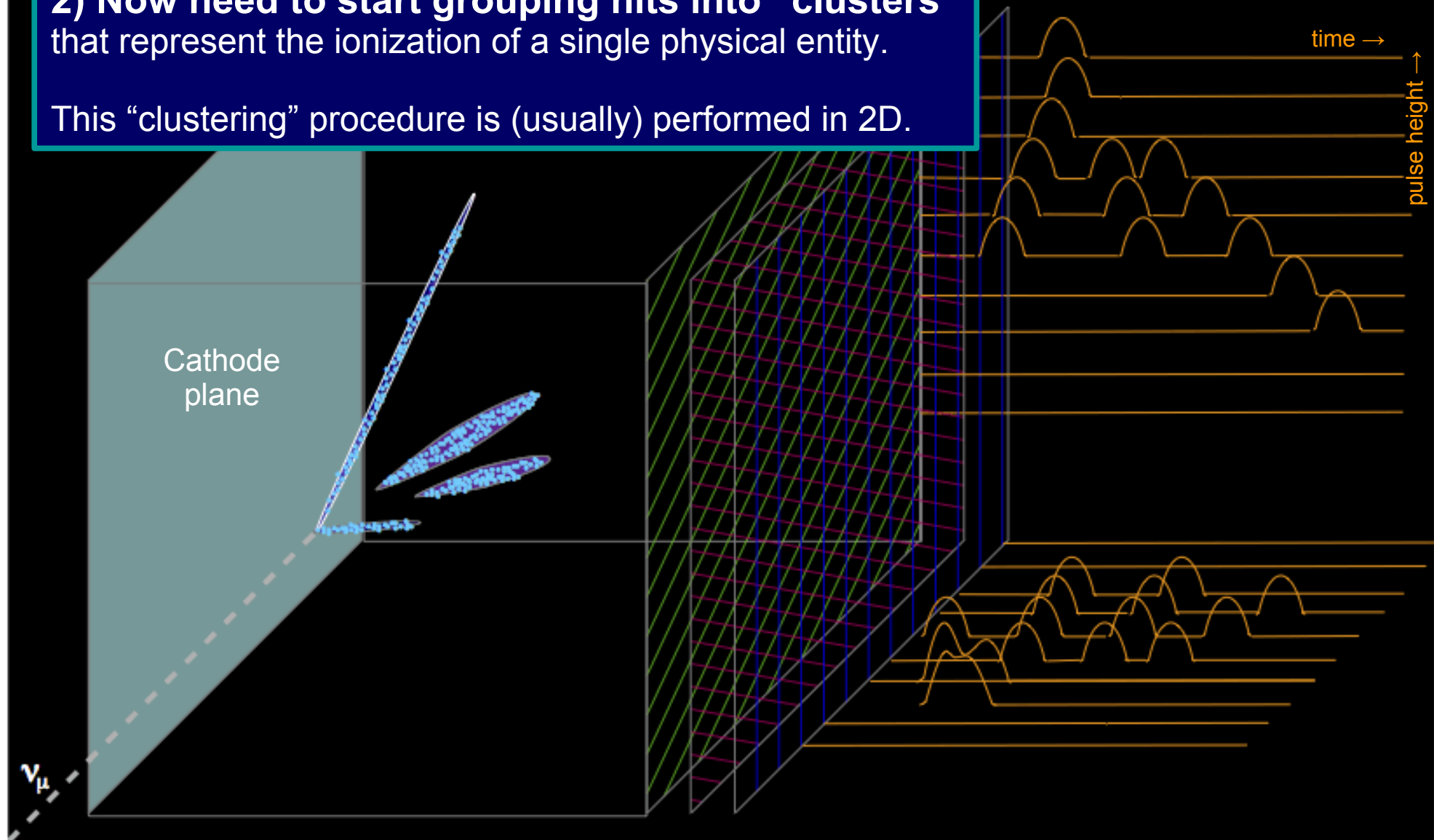
pulse height →

v_μ

Reconstruction workflow and data structures

2) Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

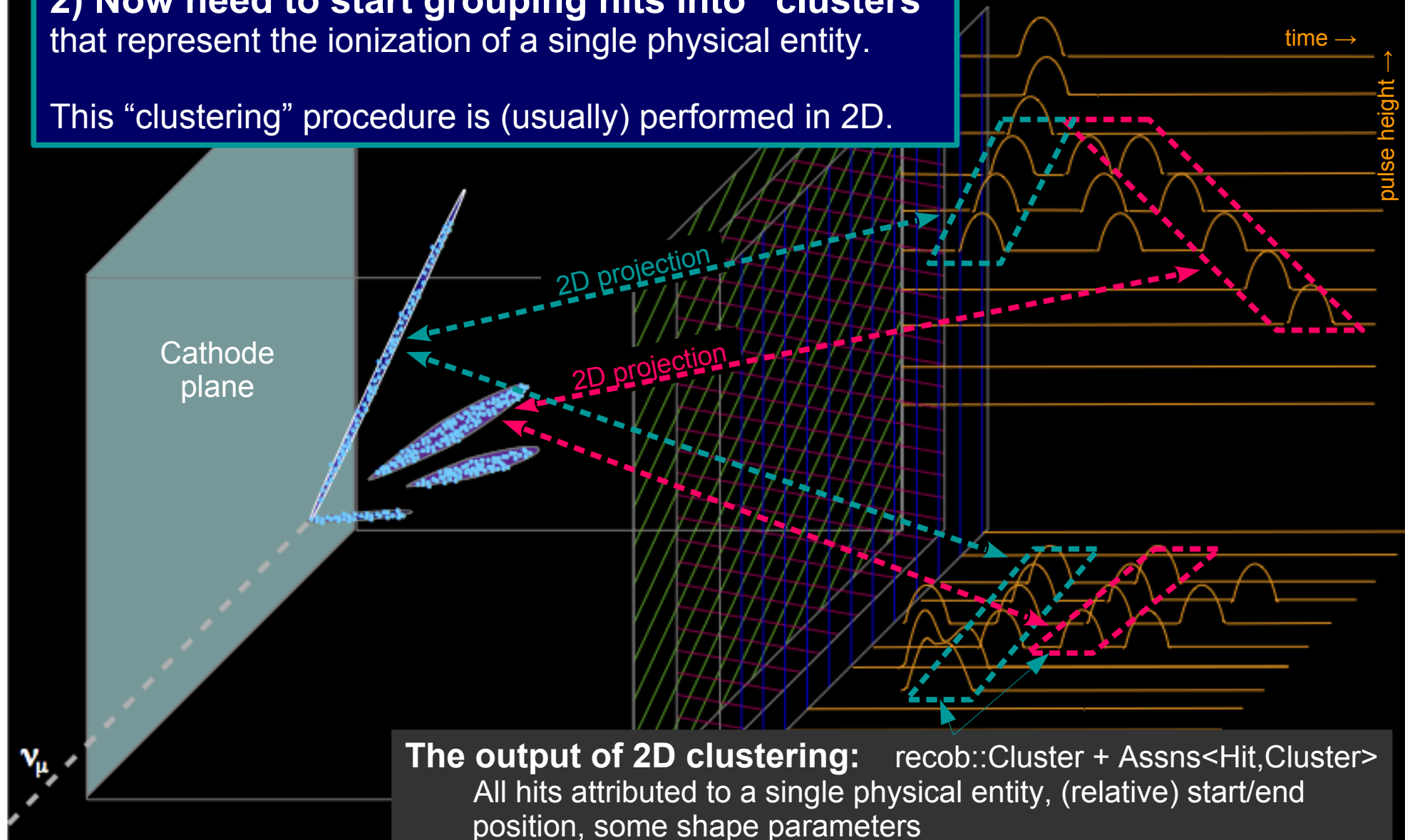
This “clustering” procedure is (usually) performed in 2D.



Reconstruction workflow and data structures

2) Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

This “clustering” procedure is (usually) performed in 2D.



The output of 2D clustering: `recob::Cluster + Assns<Hit,Cluster>`
All hits attributed to a single physical entity, (relative) start/end position, some shape parameters

Reconstruction workflow and data structures

2) Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

This “clustering” procedure is (usually) performed in 2D.

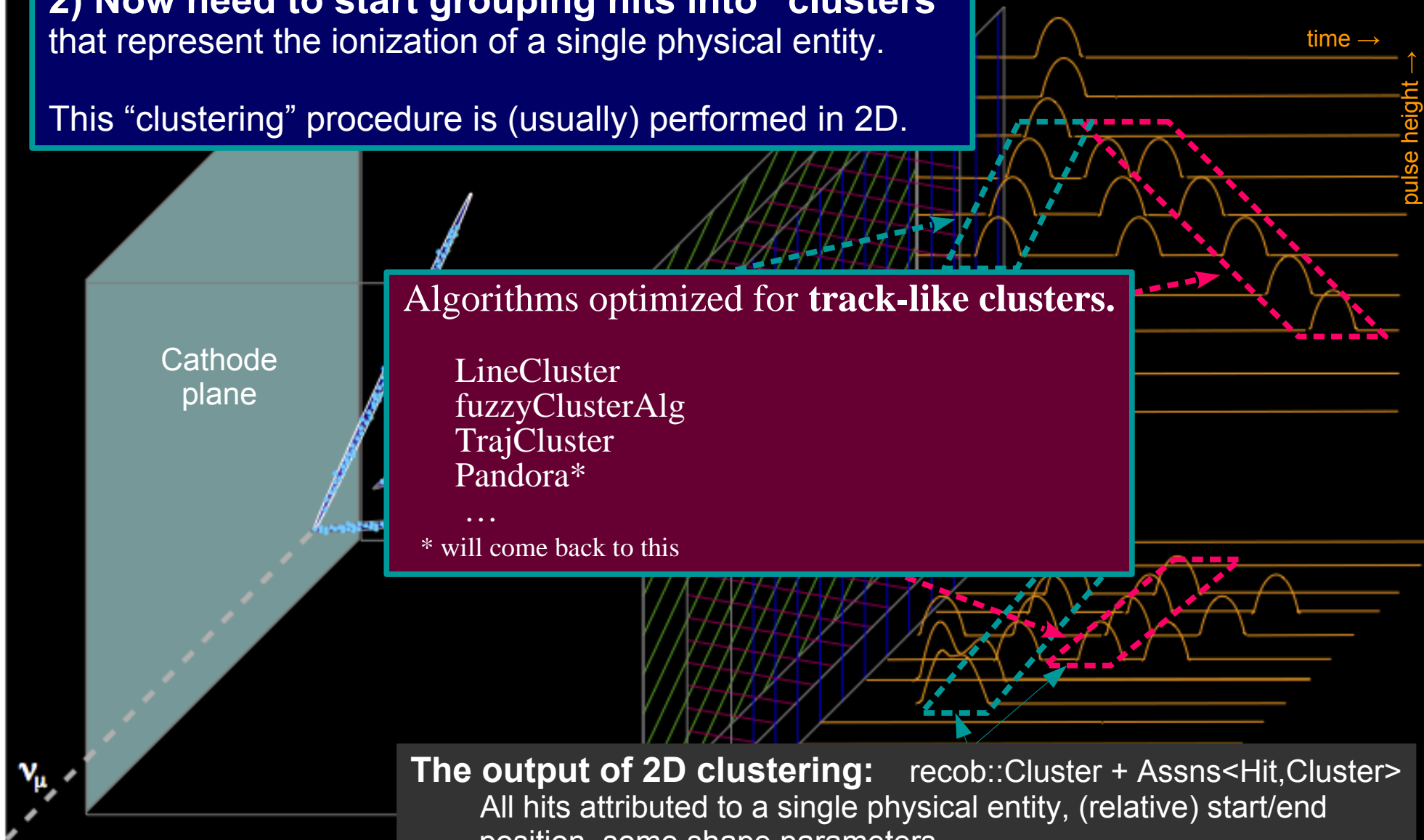
Algorithms optimized for **track-like clusters**.

LineCluster
fuzzyClusterAlg
TrajCluster
Pandora*

...

* will come back to this

The output of 2D clustering: `recob::Cluster + Assns<Hit,Cluster>`
All hits attributed to a single physical entity, (relative) start/end position, some shape parameters



Reconstruction workflow and data structures

2) Now need to start grouping hits into “clusters”
that represent the ionization of a single physical entity.

This “clustering” procedure is (usually) performed in 2D.

Algorithms optimized for shower-like clusters.

BlurredCluster
PMAlg
Pandora*

• • •

* will come back to this

The output of 2D clustering: `recob::Cluster + Assns<Hit,Cluster>`
All hits attributed to a single physical entity, (relative) start/end position, some shape parameters

Reconstruction workflow and data structures

2) Now need to start grouping hits into “clusters” that represent the ionization of a single physical entity.

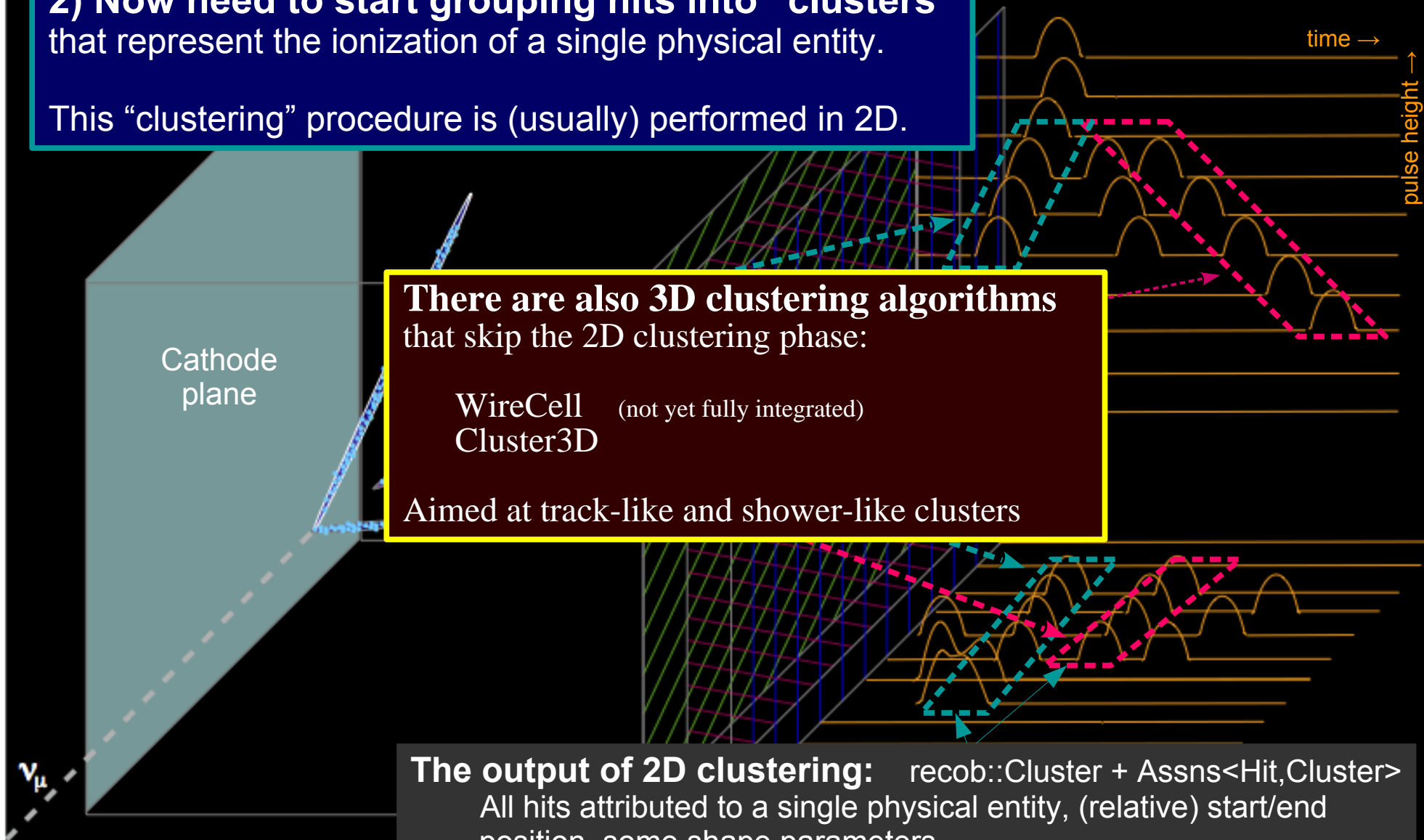
This “clustering” procedure is (usually) performed in 2D.

There are also 3D clustering algorithms that skip the 2D clustering phase:

WireCell (not yet fully integrated)
Cluster3D

Aimed at track-like and shower-like clusters

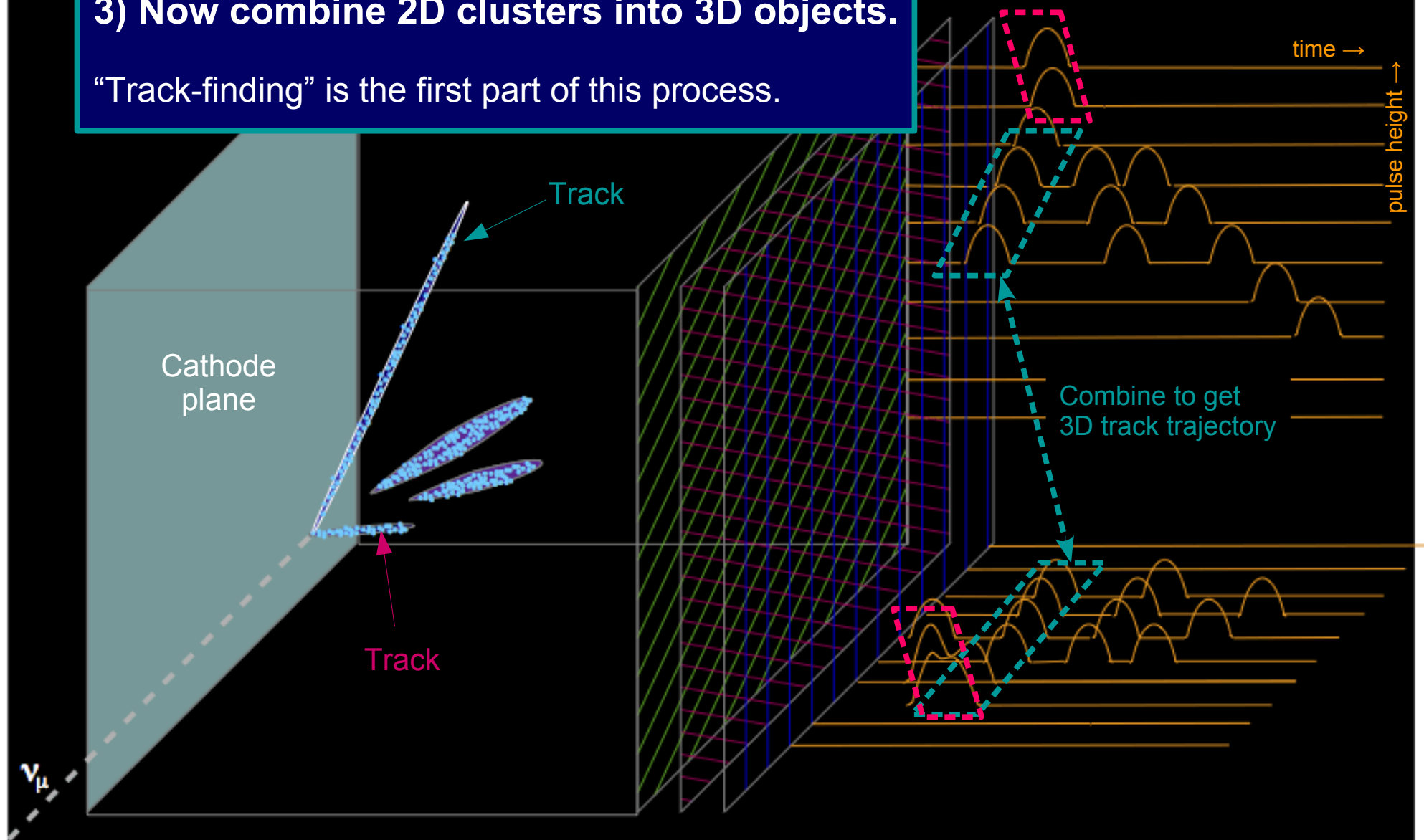
The output of 2D clustering: `recob::Cluster + Assns<Hit,Cluster>`
All hits attributed to a single physical entity, (relative) start/end position, some shape parameters



Reconstruction workflow and data structures

3) Now combine 2D clusters into 3D objects.

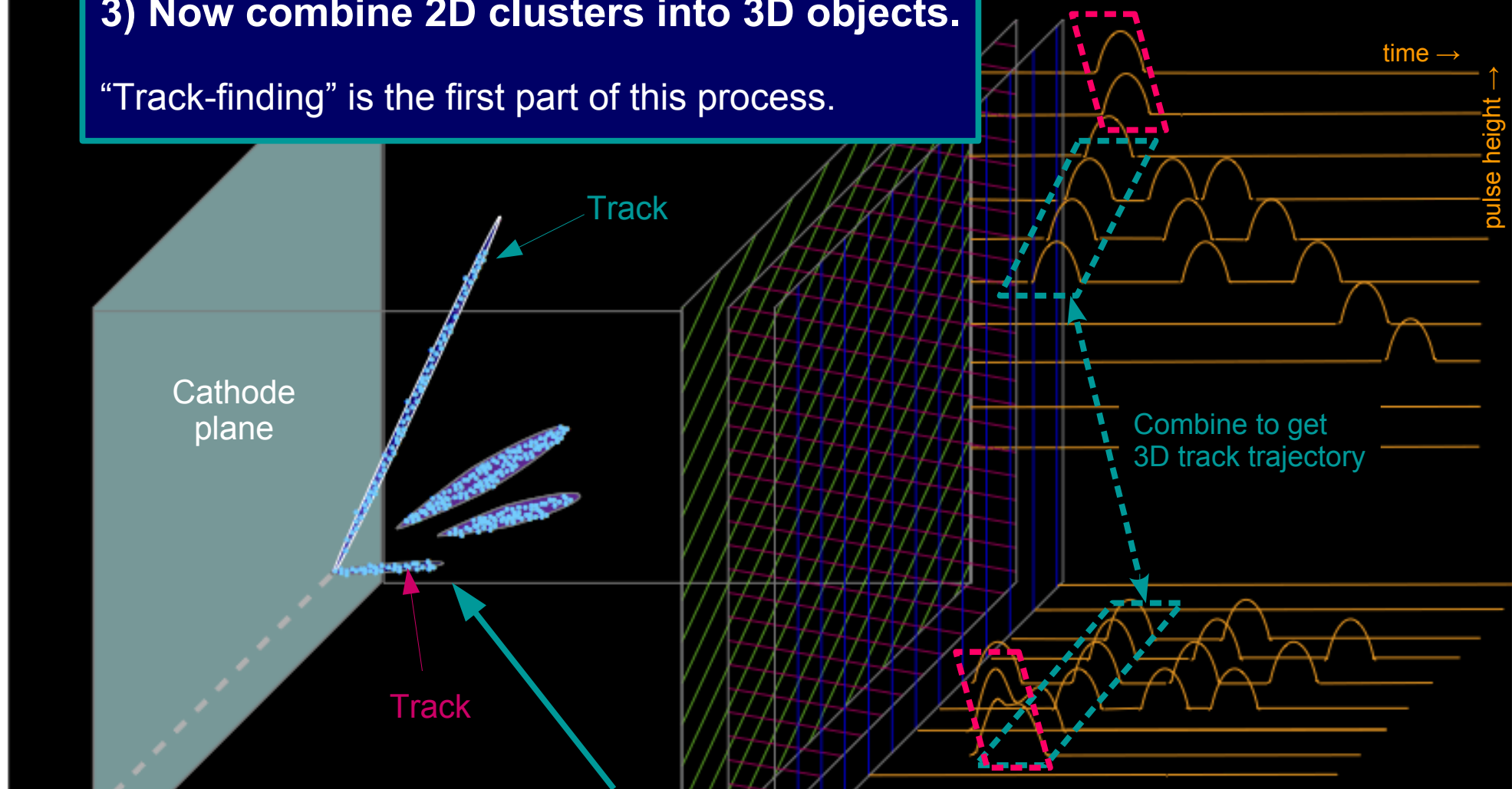
“Track-finding” is the first part of this process.



Reconstruction workflow and data structures

3) Now combine 2D clusters into 3D objects.

“Track-finding” is the first part of this process.



The output of tracking: `recob::Track + Assns<Cluster,Track>`
Estimated points + direction + covariance along trajectory
Tracks can also have associated `recob::Vertex` objects
and `recob::PFParticle` objects (preliminary particle flow hypotheses)

Reconstruction workflow and data structures

3) Now combine 2D clusters into 3D objects.

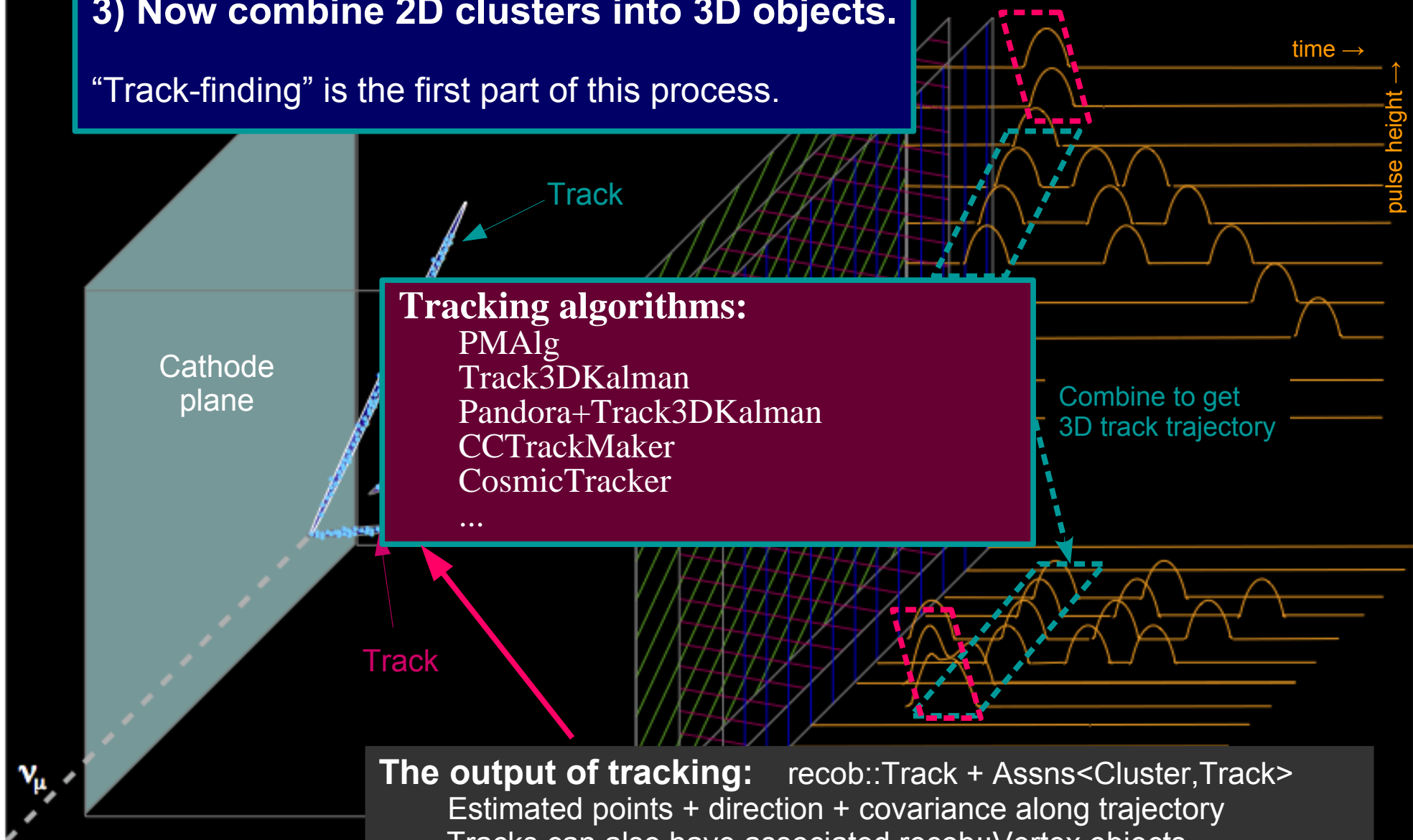
“Track-finding” is the first part of this process.

Tracking algorithms:

- PMAIlg
- Track3DKalman
- Pandora+Track3DKalman
- CCTrackMaker
- CosmicTracker
- ...

Combine to get
3D track trajectory

The output of tracking: `recob::Track + Assns<Cluster,Track>`
Estimated points + direction + covariance along trajectory
Tracks can also have associated `recob::Vertex` objects
and `recob::PFParticle` objects (preliminary particle flow hypotheses)

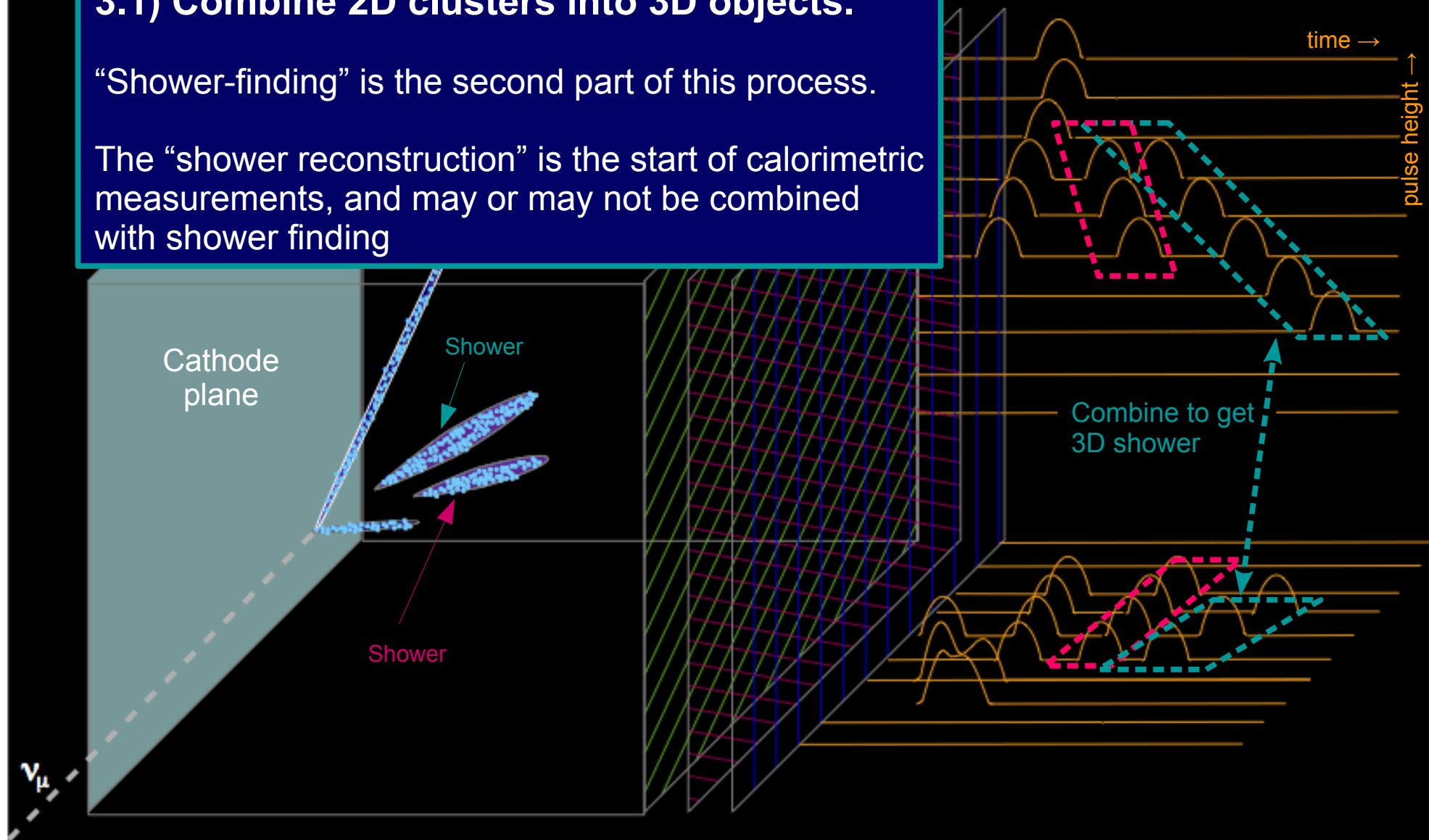


Reconstruction workflow and data structures

3.1) Combine 2D clusters into 3D objects.

“Shower-finding” is the second part of this process.

The “shower reconstruction” is the start of calorimetric measurements, and may or may not be combined with shower finding

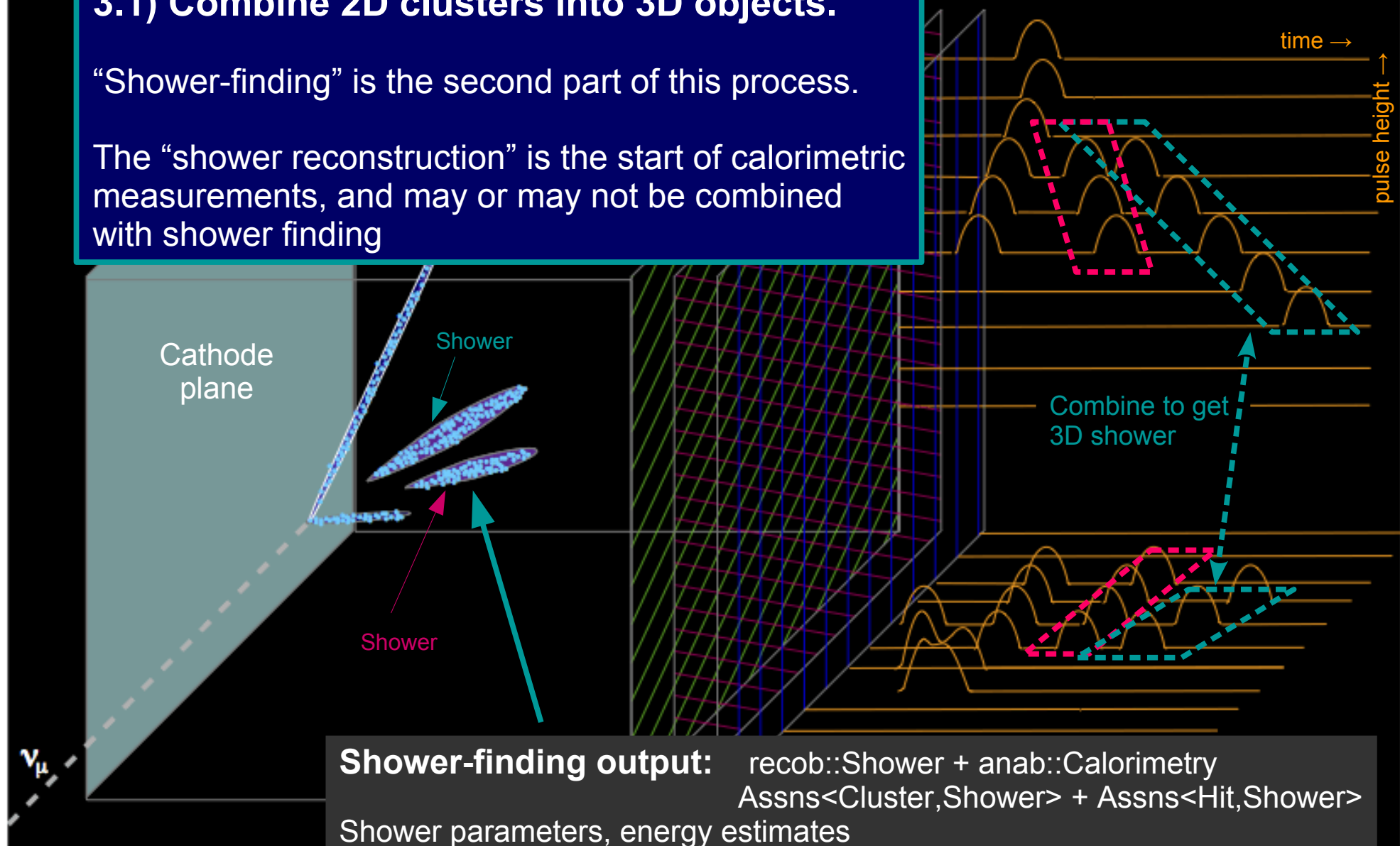


Reconstruction workflow and data structures

3.1) Combine 2D clusters into 3D objects.

“Shower-finding” is the second part of this process.

The “shower reconstruction” is the start of calorimetric measurements, and may or may not be combined with shower finding



Reconstruction workflow and data structures

3.1) Combine 2D clusters into 3D objects.

“Shower-finding” is the second part of this process.

The “shower reconstruction” is the start of calorimetric measurements, and may or may not be combined with shower finding

Cathode
plane

Shower

Shower-finding algorithms:

EMShower
ShowerReco3D
PMA1g
Pandora
(some private uBooNE analysis code soon to be integrated)
...

Shower-finding output: recob::Shower + anab::Calorimetry
Assns<Cluster,Shower> + Assns<Hit,Shower>
Shower parameters, energy estimates

time →

pulse height →

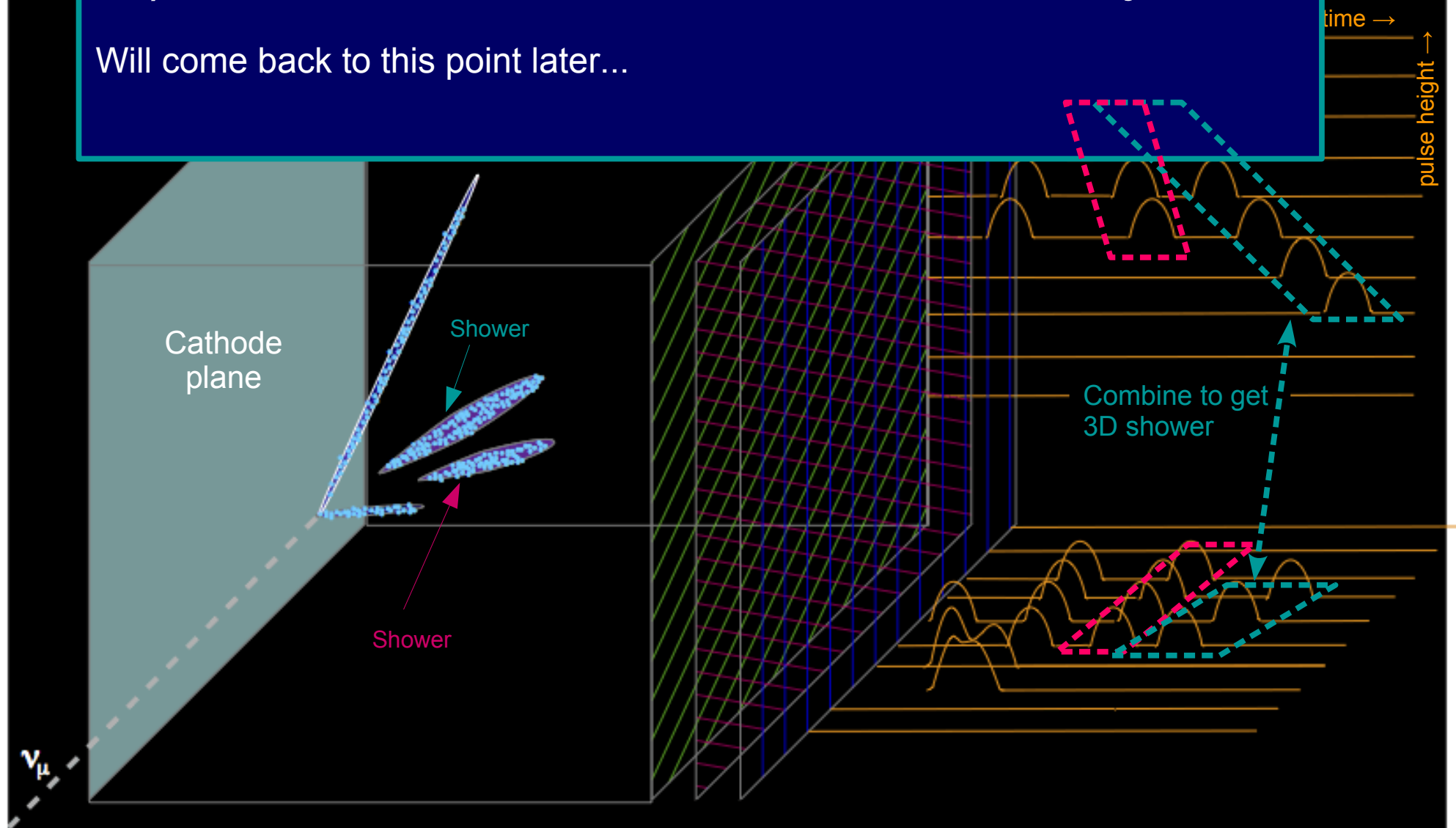
line to get
lower

ν_μ

Reconstruction workflow and data structures

3.2) Can assemble 2D clusters into hierarchies of 3D objects

Will come back to this point later...

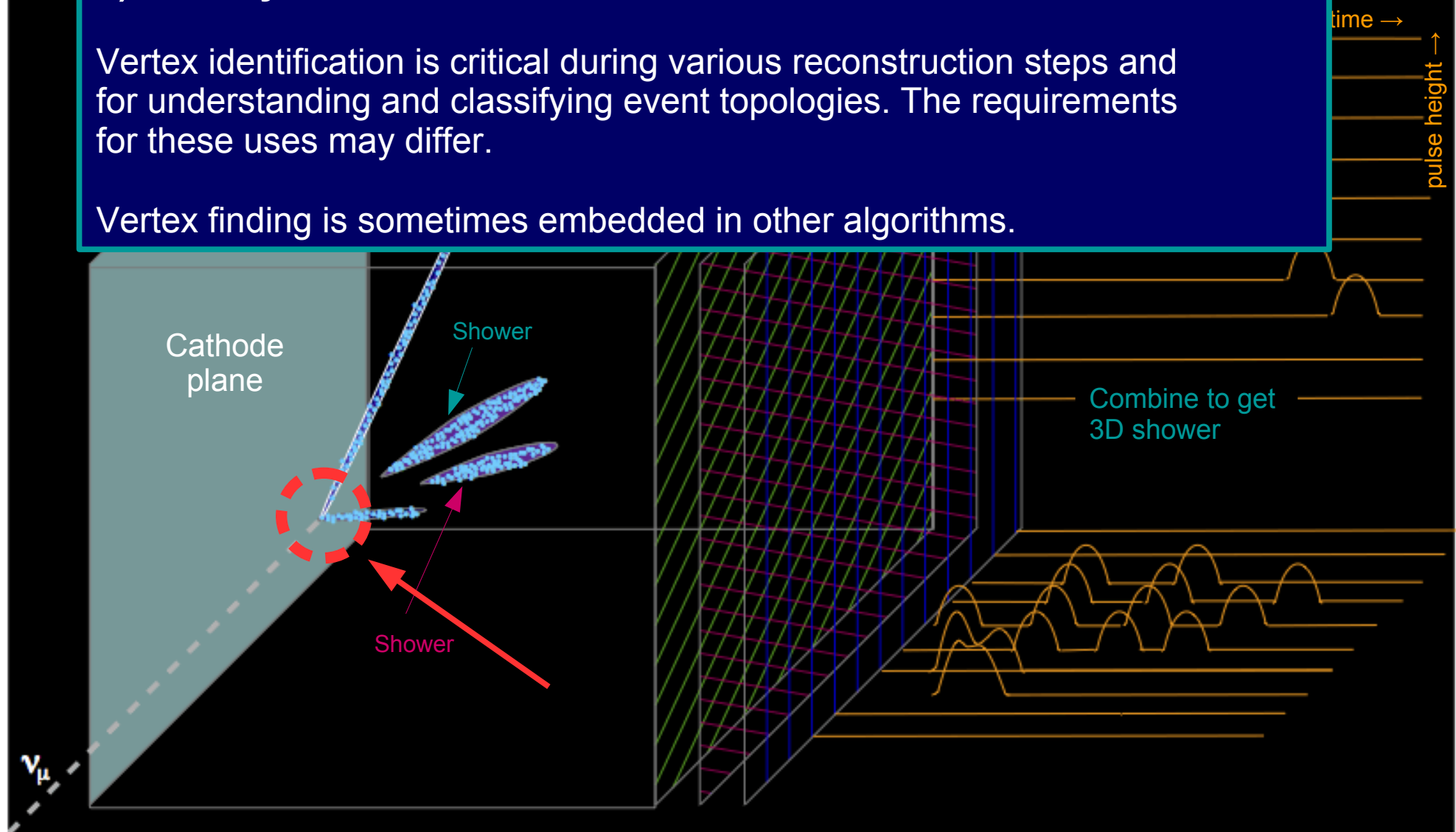


Reconstruction workflow and data structures

4) Identify vertices in the event from tracks in the event

Vertex identification is critical during various reconstruction steps and for understanding and classifying event topologies. The requirements for these uses may differ.

Vertex finding is sometimes embedded in other algorithms.

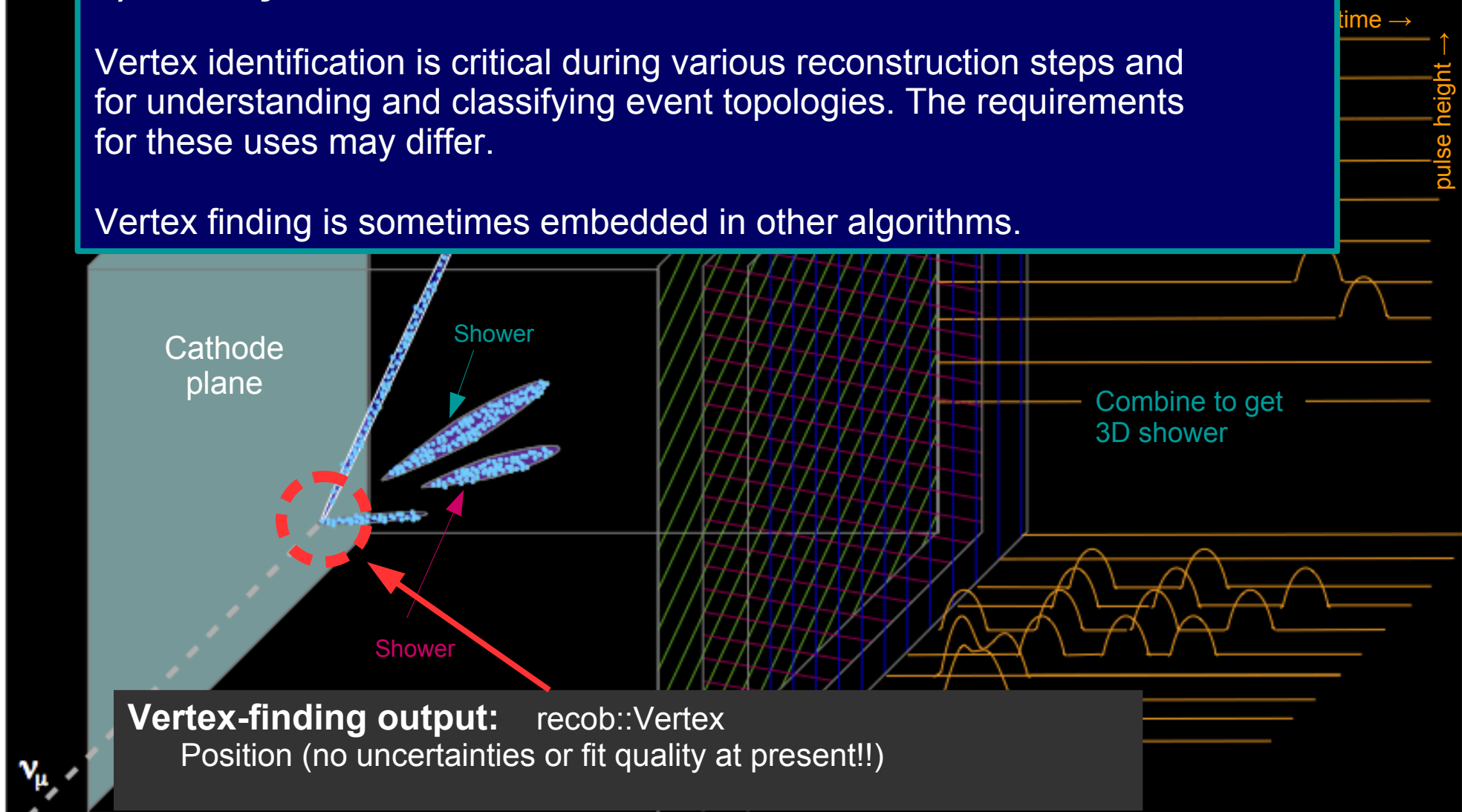


Reconstruction workflow and data structures

4) Identify vertices in the event from tracks in the event

Vertex identification is critical during various reconstruction steps and for understanding and classifying event topologies. The requirements for these uses may differ.

Vertex finding is sometimes embedded in other algorithms.



Reconstruction workflow and data structures

4) Identify vertices in the event from tracks in the event

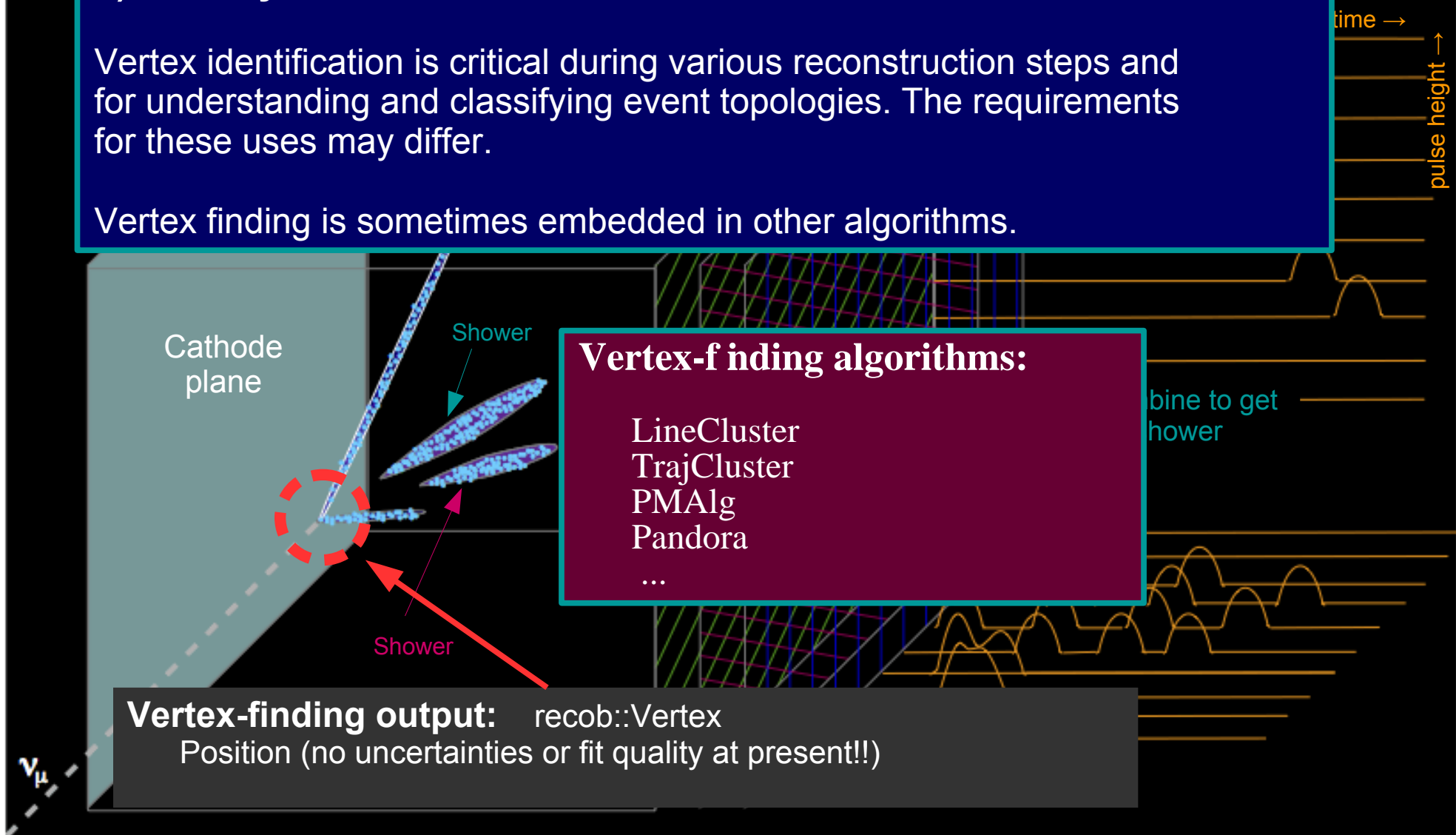
Vertex identification is critical during various reconstruction steps and for understanding and classifying event topologies. The requirements for these uses may differ.

Vertex finding is sometimes embedded in other algorithms.

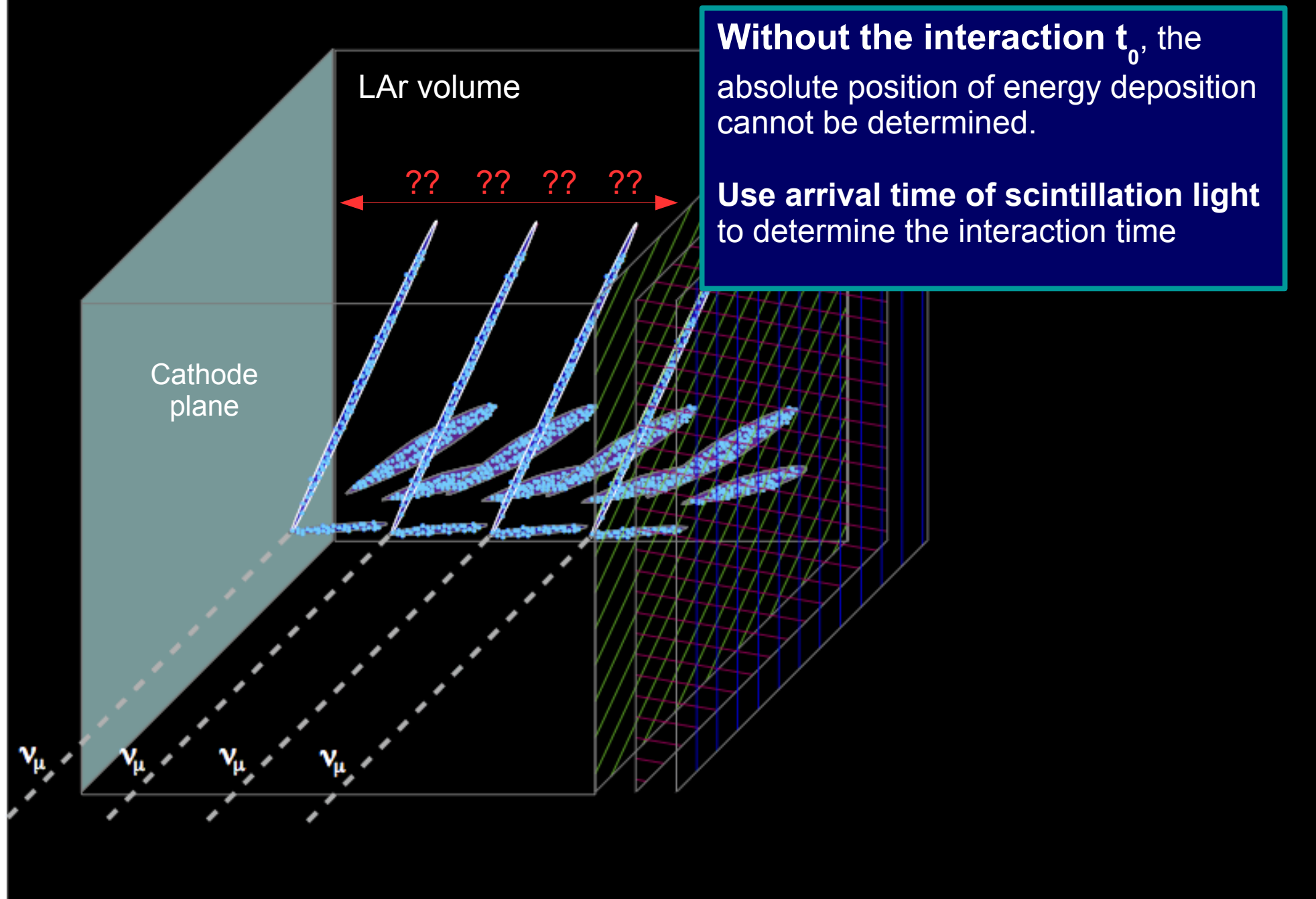
Vertex-finding algorithms:

- LineCluster
- TrajCluster
- PMAlg
- Pandora
- ...

Vertex-finding output: `recob::Vertex`
Position (no uncertainties or fit quality at present!!)



Reconstruction workflow and data structures



Reconstruction workflow and data structures

LAr volume

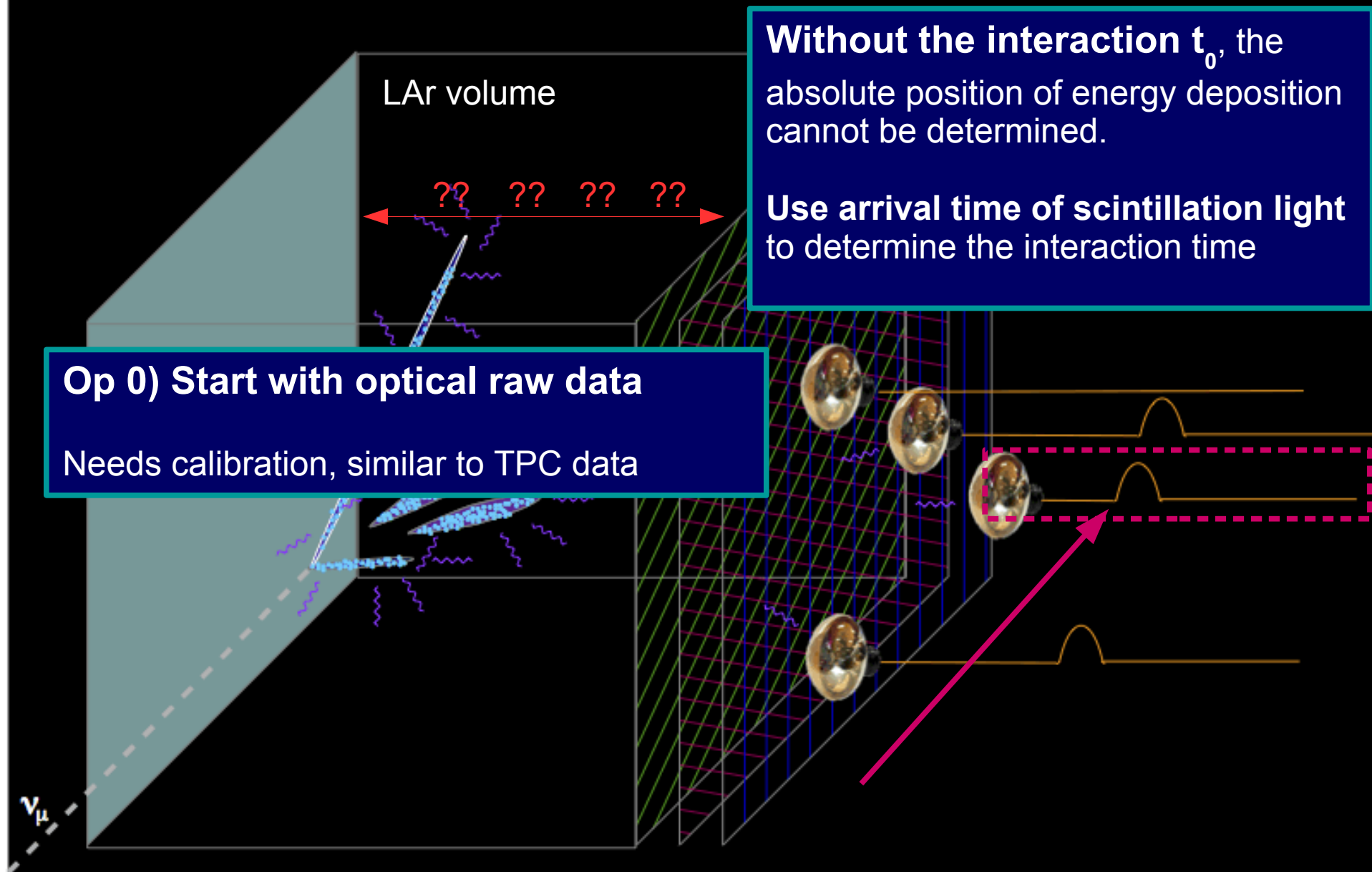
Without the interaction t_0 , the absolute position of energy deposition cannot be determined.

Use arrival time of scintillation light to determine the interaction time

Op 0) Start with optical raw data

Needs calibration, similar to TPC data

ν_μ



Reconstruction workflow and data structures

LAr volume

Without the interaction t_0 , the absolute position of energy deposition cannot be determined.

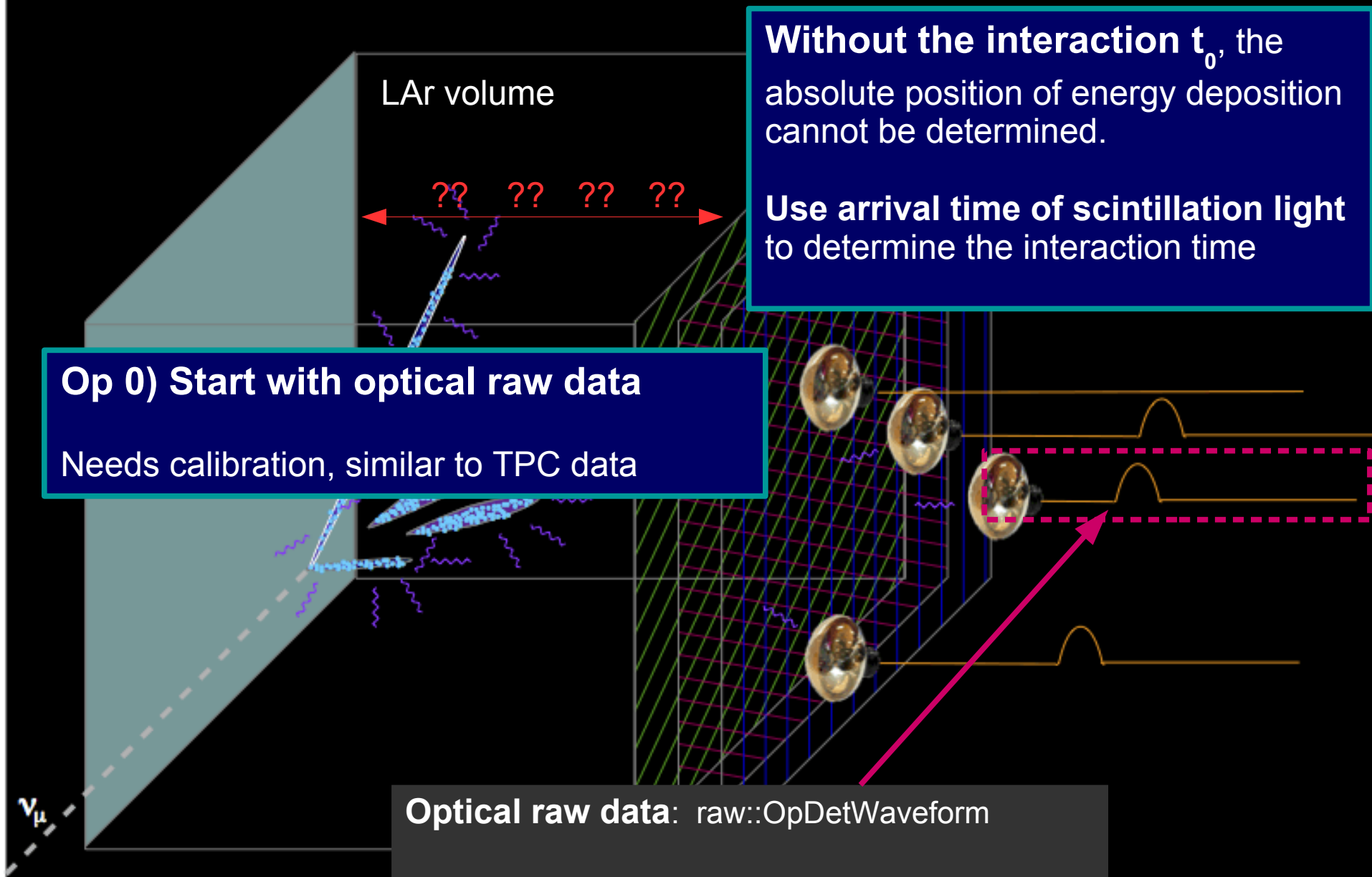
Use arrival time of scintillation light to determine the interaction time

Op 0) Start with optical raw data

Needs calibration, similar to TPC data

Optical raw data: `raw::OpDetWaveform`

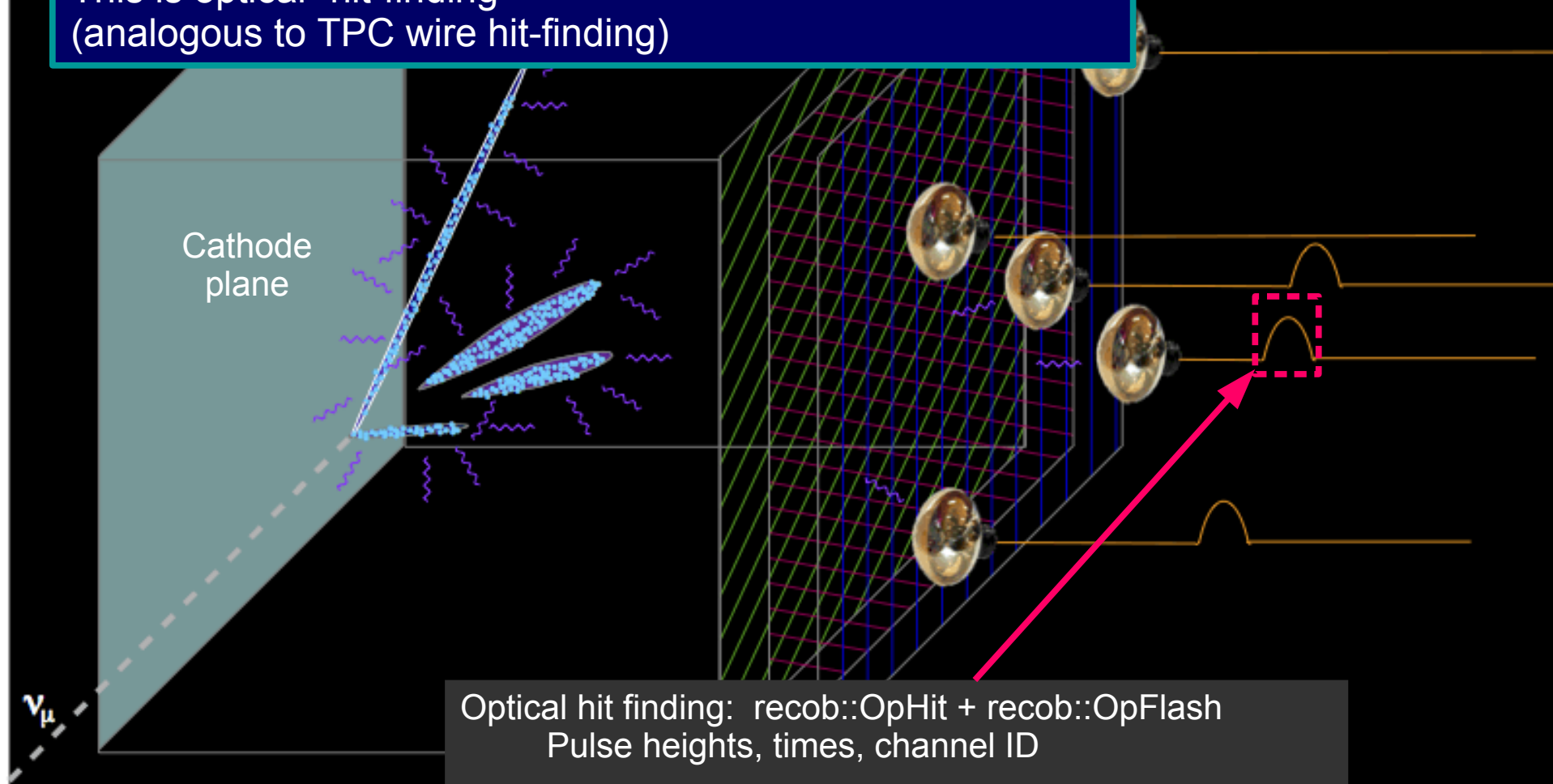
ν_μ



Reconstruction workflow and data structures

Op 1) First identify signals from single interactions on each optical channel

This is optical “hit-finding”
(analogous to TPC wire hit-finding)



Reconstruction workflow and data structures

Op 1) First identify signals from single interactions on each optical channel

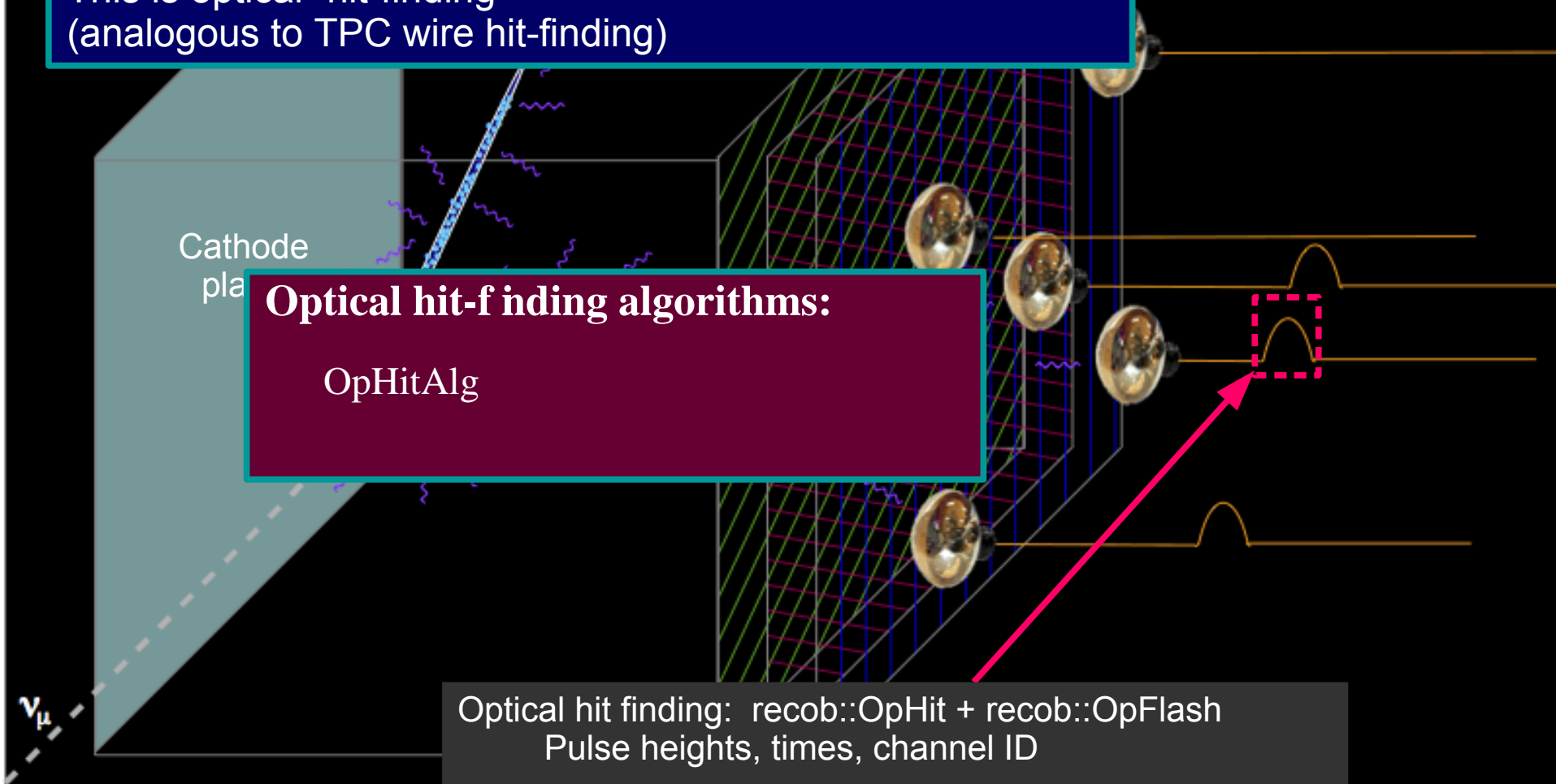
This is optical “hit-finding”
(analogous to TPC wire hit-finding)

Cathode
plane

Optical hit-finding algorithms:

OpHitAlg

Optical hit finding: `recob::OpHit` + `recob::OpFlash`
Pulse heights, times, channel ID

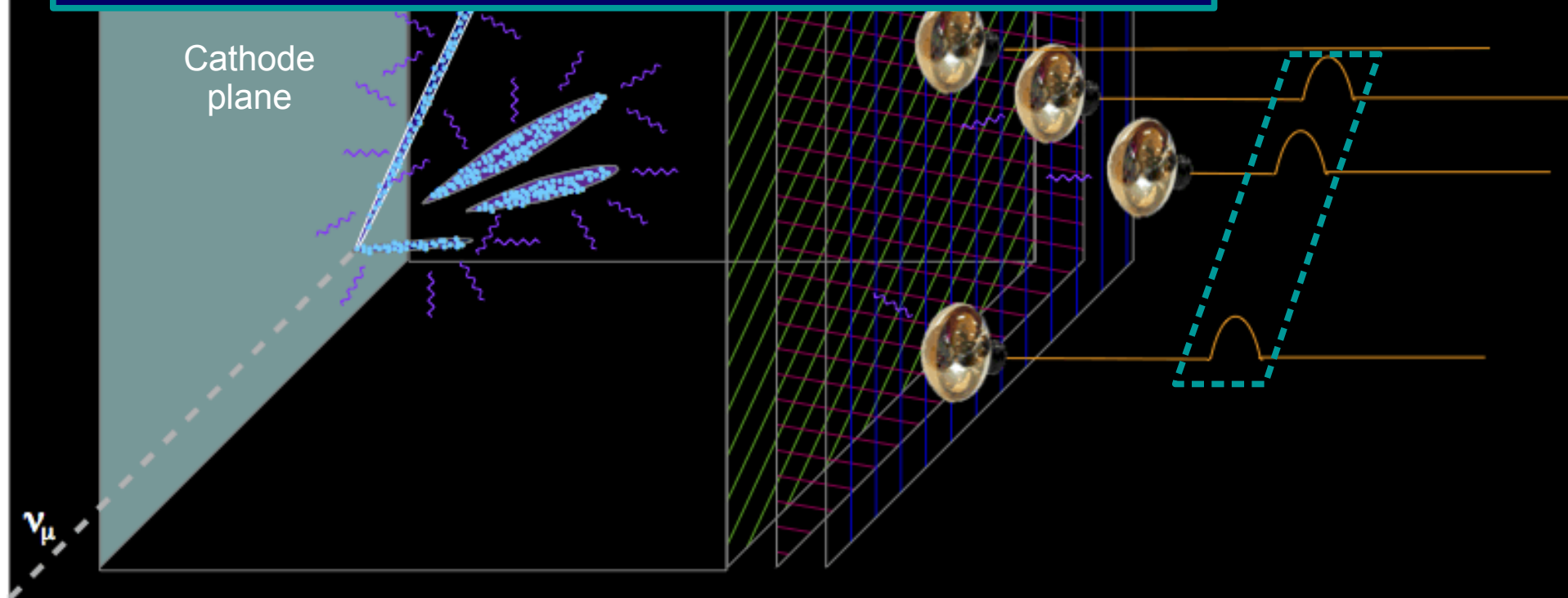


Reconstruction workflow and data structures

Op 2) Find all hits associated with a single interaction in the TPC.

All tracks, showers from a single interaction produce a “flash”.
“Flash-finding” identifies all such associated hits.

The combination of hit and flash finding is sometimes called
“optical reconstruction”

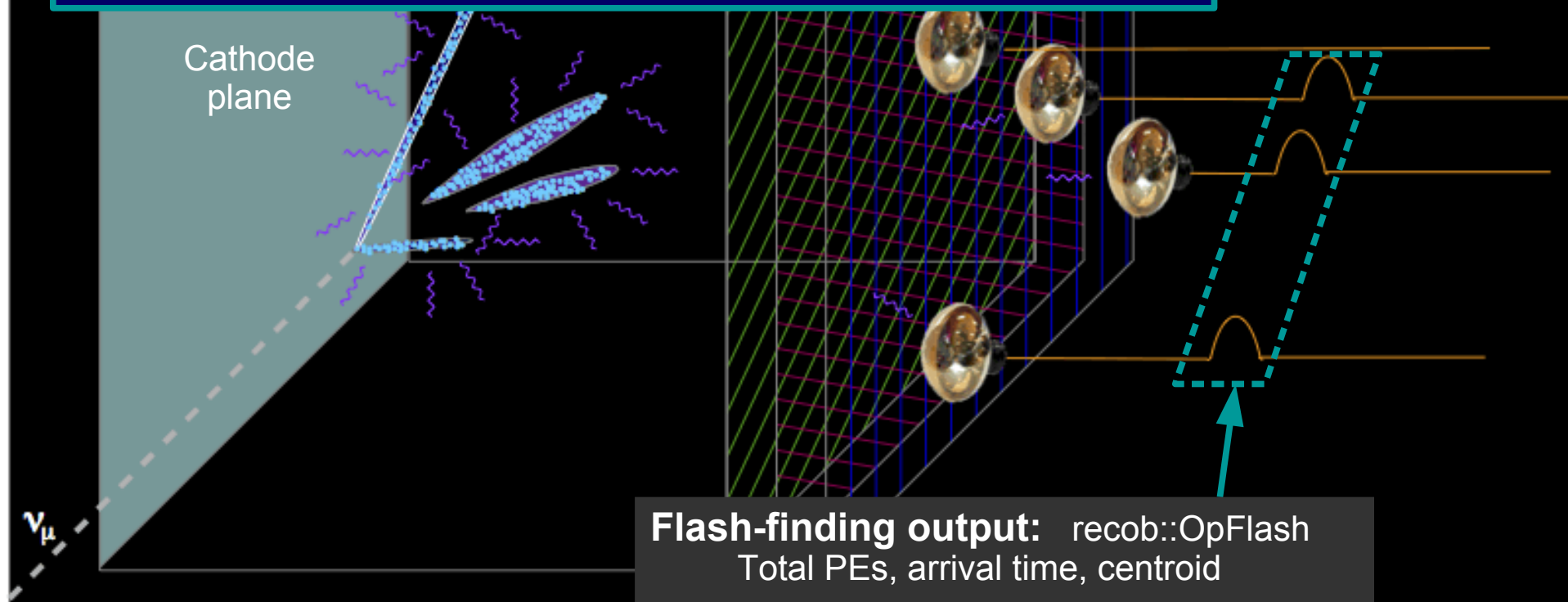


Reconstruction workflow and data structures

Op 2) Find all hits associated with a single interaction in the TPC.

All tracks, showers from a single interaction produce a “flash”.
“Flash-finding” identifies all such associated hits.

The combination of hit and flash finding is sometimes called
“optical reconstruction”

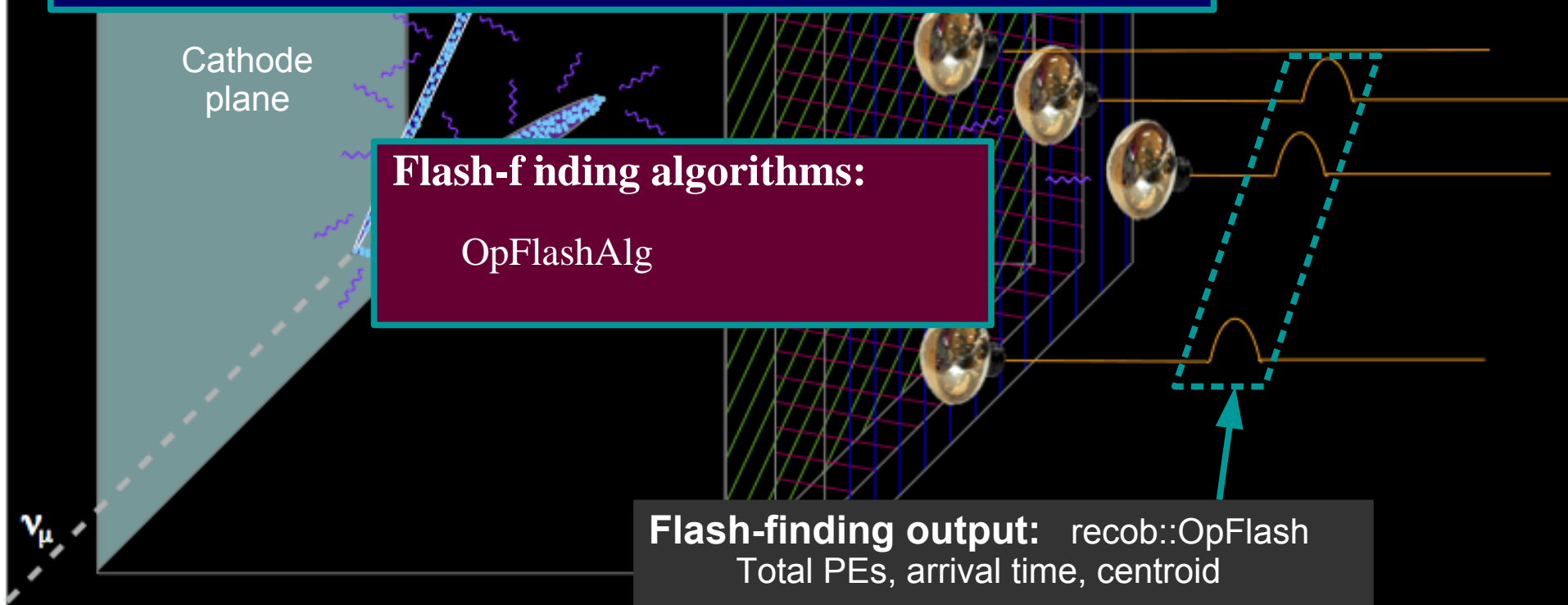


Reconstruction workflow and data structures

Op 2) Find all hits associated with a single interaction in the TPC.

All tracks, showers from a single interaction produce a “flash”.
“Flash-finding” identifies all such associated hits.

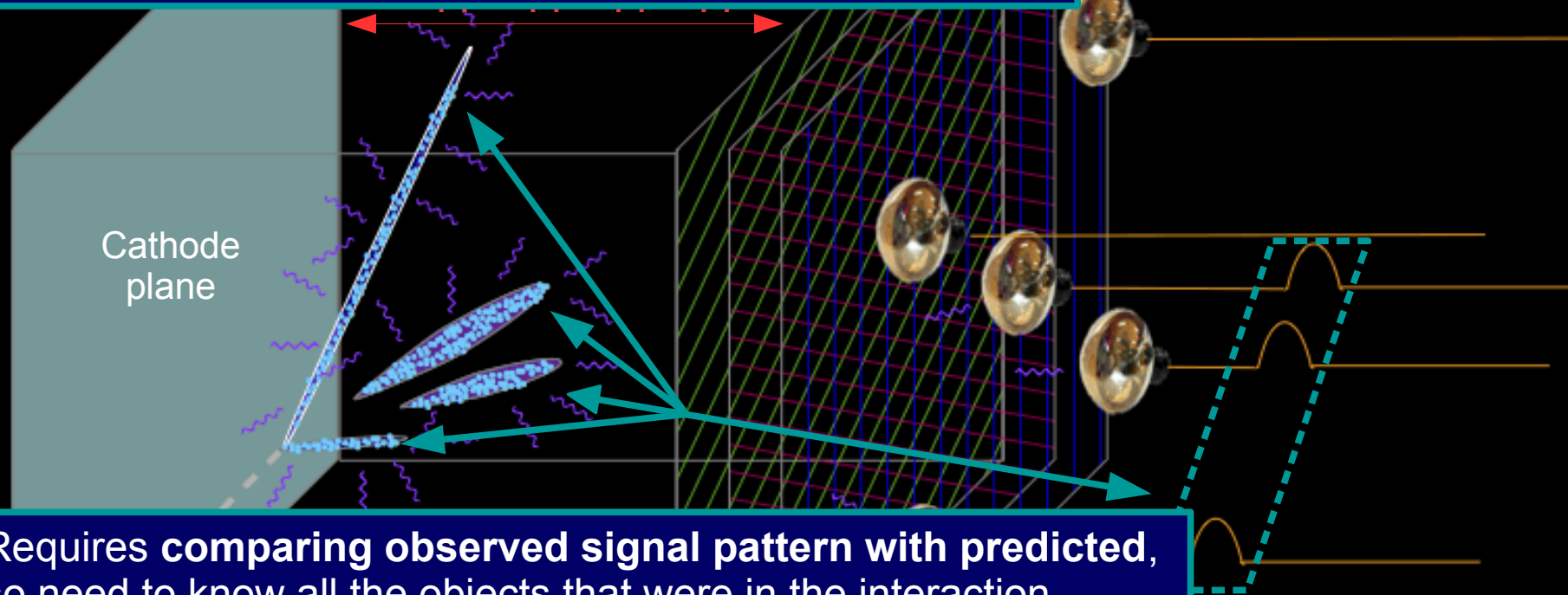
The combination of hit and flash finding is sometimes called
“optical reconstruction”



Reconstruction workflow and data structures

Op 3) Now match a given flash to a set of objects
from a single interaction event in the TPC

This step is “flash-matching”



Requires **comparing observed signal pattern with predicted**,
so need to know all the objects that were in the interaction
Estimate event t_0 from this process.

Because it requires an event hypothesis, **may be performed**
at analysis-level rather than at primary reconstruction

Reconstruction workflow and data structures

Op 3) Now match a given flash to a set of objects
from a single interaction event in the TPC

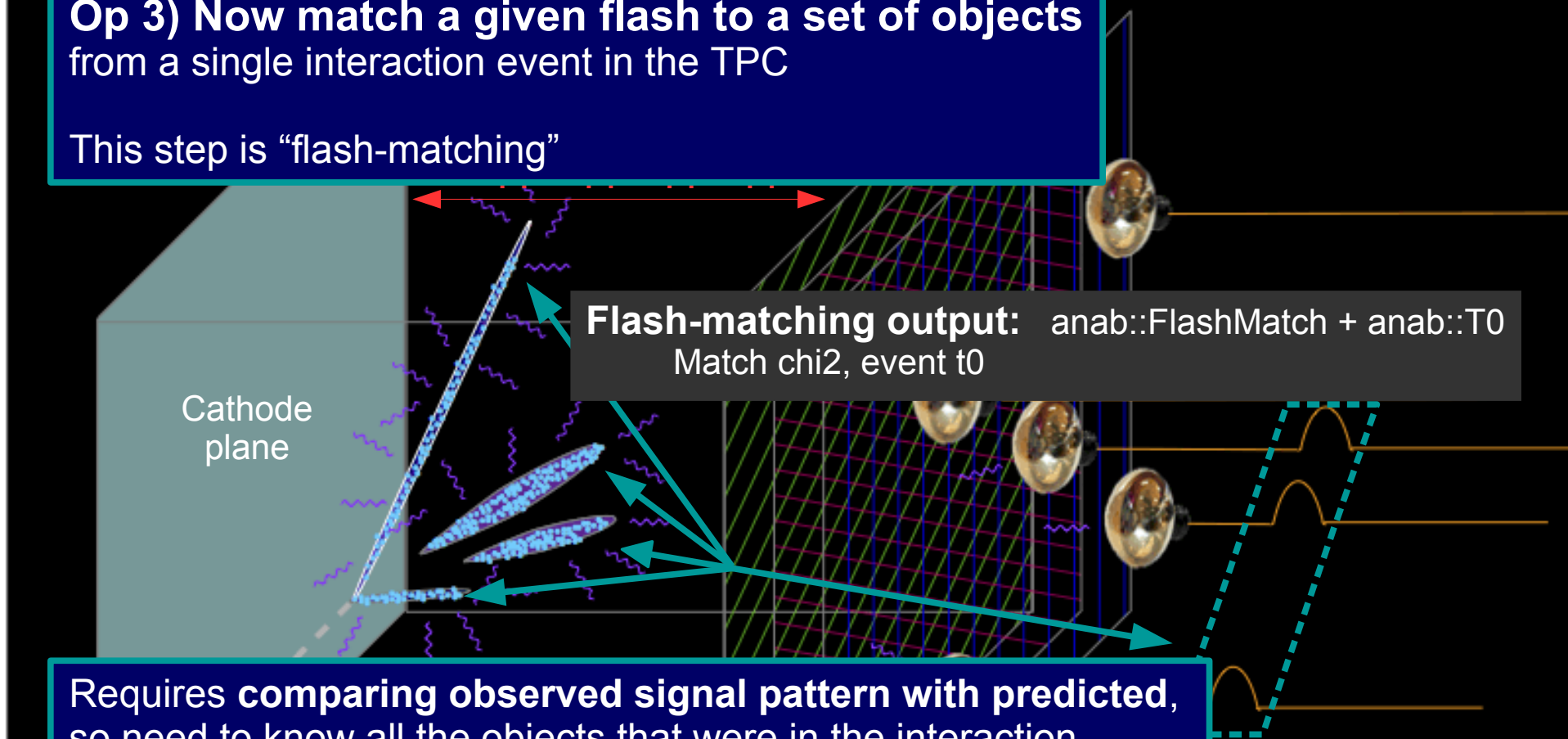
This step is “flash-matching”

Flash-matching output: `anab::FlashMatch + anab::T0`
Match χ^2 , event t_0

Cathode plane

Requires **comparing observed signal pattern with predicted**,
so need to know all the objects that were in the interaction
Estimate event t_0 from this process.

Because it requires an event hypothesis, **may be performed at analysis-level** rather than at primary reconstruction



Special algorithm notes

Pandora

- Multi-algorithm pattern recognition framework

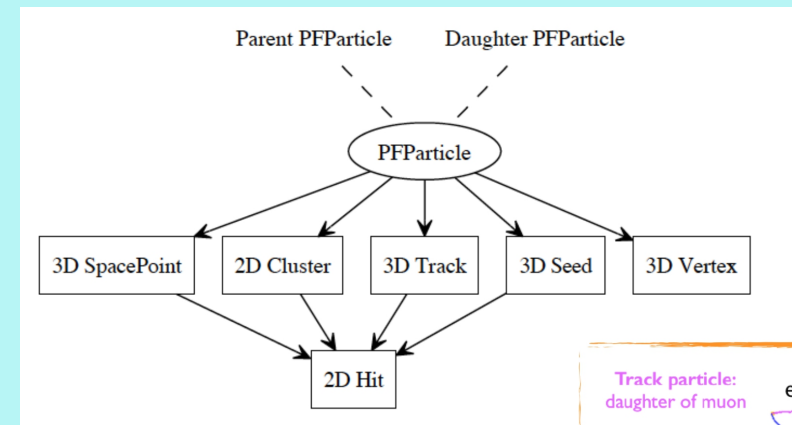
See [Lorena Escuerdo's talk on Pandora from Wednesday](#)

- Takes recob::Hit collections as input, and performs

- 2D cluster finding (track-like and shower-like)
- 3D matching
- shower/track discrimination
- vertex finding and classification

- Produces recob::PFParticles

- Mother-daughter hierarchy for all particles from a single event vertex
 - Distinguish tracks, delta rays, showers, vertices



Pandora

- Multi-algorithm pattern recognition framework

See [Lorena Escuerdo's talk on Pandora from Wednesday](#)

- Takes reco

- 2D cl
- 3D m
- show
- verte

- Produces

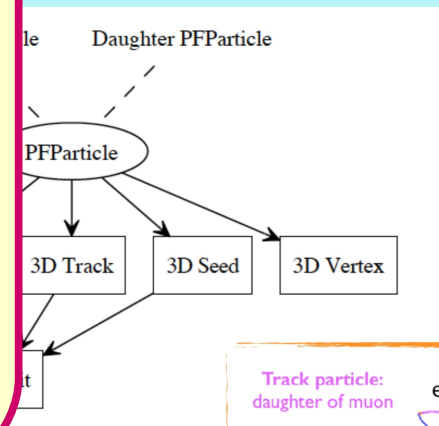
- Moth
- from

- Dis
- vertices

Developed externally to LArSoft

- Dedicated, direct interface modules in LArSoft
- Typically run in stages with intervening LArSoft algorithms

e.g., Pandora cosmic tagging
→ LArSoft cosmic hit removal
→ Pandora neutrino event reco



Wire-cell

- 3D object reconstruction from 2D time slices

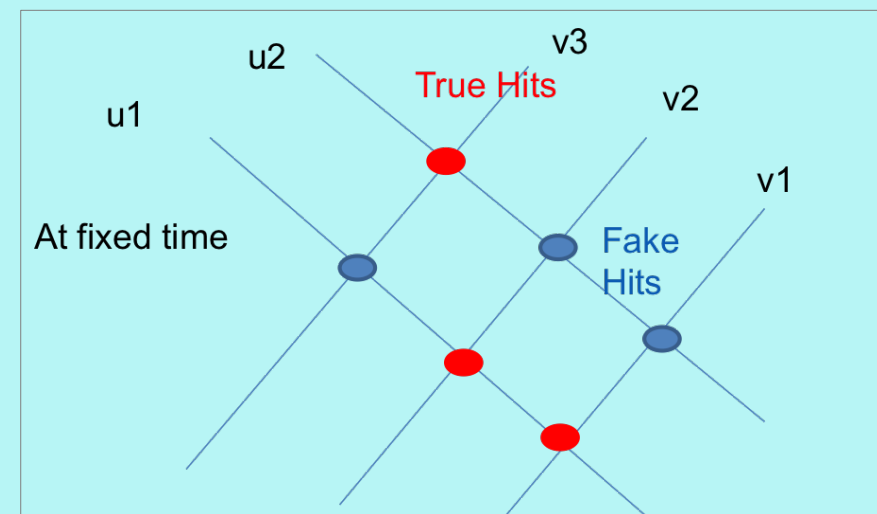
See <http://www.phy.bnl.gov/wire-cell/>

- Uses charge as constraint to assign hits values at each wire crossing

- Demanding signal processing requirements
- Computationally challenging
- High reward

- Developed externally to LArSoft

- Direct, multipoint interfacing to LArSoft in progress
- May also drive data product evolution



Deep learning networks

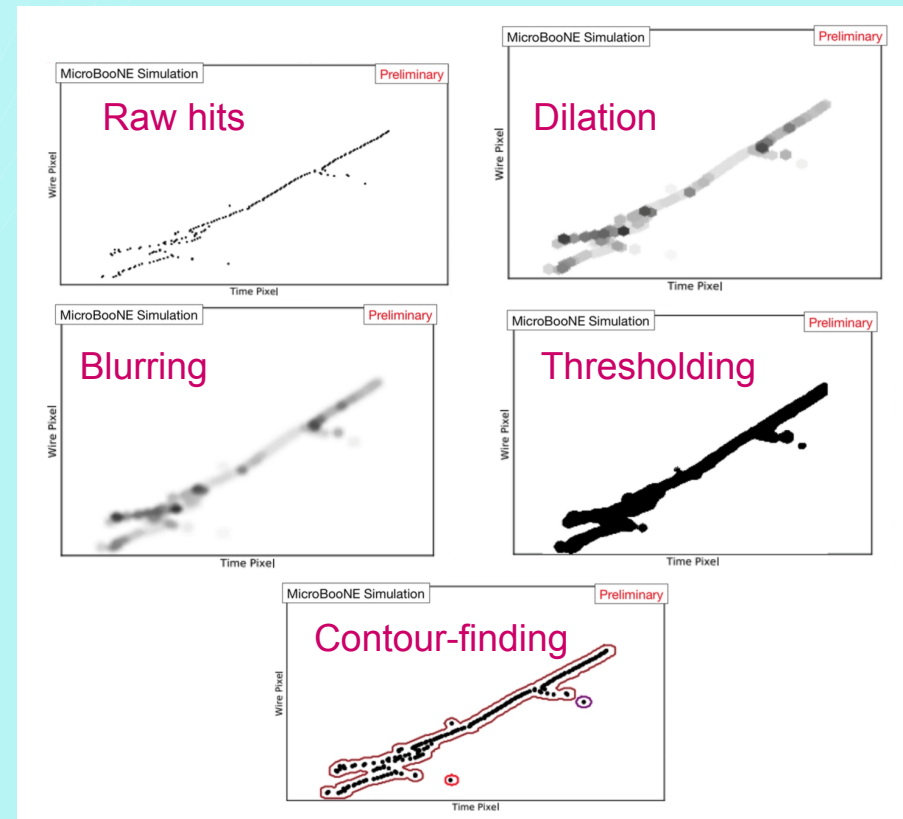
- A variety of efforts are in progress
 - At present, aimed mainly at event classification, region of interest identification, track/shower discrimination
- One already integrated into LArSoft

[See talk by P. Plonski, D. Stefan, R. Sulej on Wednesday](#)

 - Provide hit-level shower/track discrimination and vertex identification upstream of conventional LArSoft algorithms
- Much to learn about how to use these types of algorithms
 - Envision continuing integration work

Image processing techniques

- MicroBooNE effort underway to perform 2D clustering with image processing software
 - Topology-based clustering
 - OpenCV product applied to 2D TPC image data
 - interesting early results
- Future work
 - How to use this technique
 - How to integrate into LArSoft



From [MicroBooNE-Note-1012-Pub](#)

Other techniques...

...that I've not mentioned, or am not aware of

Still lots of room for innovation, evolution, so be bold!!

Additional reconstruction considerations

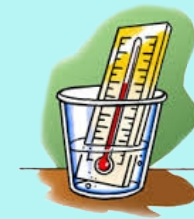
Additional reconstruction phases

- Cosmic ray removal

- Particularly important for surface detectors
 - SBN detectors at Fermilab
 - Test beam detectors
- Current algorithms primarily geometry-based
 - Look for out of time tracks, or in-time tracks that cross a boundary
 - CR hits can be removed for downstream clustering / tracking / shower-finding
- Representative algorithms:
 - CosmicTrackTagger
 - CosmicPFParticleTagger
- Output: `anab::CosmicTag`



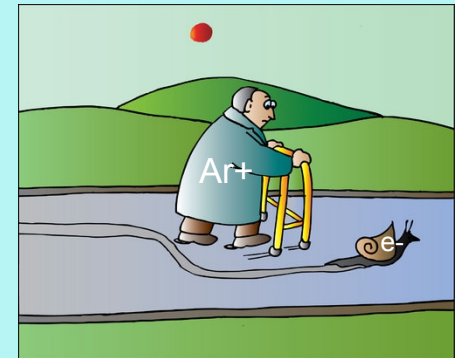
Additional reconstruction phases



- Non-shower calorimetric measurements
 - Energy and dE/dx estimates for Tracks
 - Representative algorithms: CalorimetryAlg, TrackCalorimetryAlg
 - Output: `anab::Calorimetry`
- Momentum estimation and particle identification
 - Use range, dE/dx and multiple Coulomb scattering of tracks
 - Representative algorithms:
 - Track3DKalmanHit, TrajCluster yield MCS momentum
 - Chi2PIDAlg, PIDAAlg perform particle ID
 - Output: `anab::ParticleID`, `Assns<Track, ParticlePID>`, or `TTree`

Other complications

- Space-charge distortions
 - Ion drift mobilities about $10^6\times$ smaller than for electrons
 - Cation drift velocities are $\sim \text{nm} / \mu\text{s} !!$
 - **For surface detectors**, cosmic rays introduces large (+) ion load
 - At **ProtoDUNE SP**, electron drift distortions reach **few 10's cm scale**
 - Need to map and correct for these field distortions
 - A common service interface exists to access the offsets
 - Allows experiment-dependent implementations
- Charge attenuation
 - Electron lifetime can be comparable to maximum drift time
 - Charge yield at wires will be drift-length dependent
 - Affects S:N ratio and charge / energy measurements



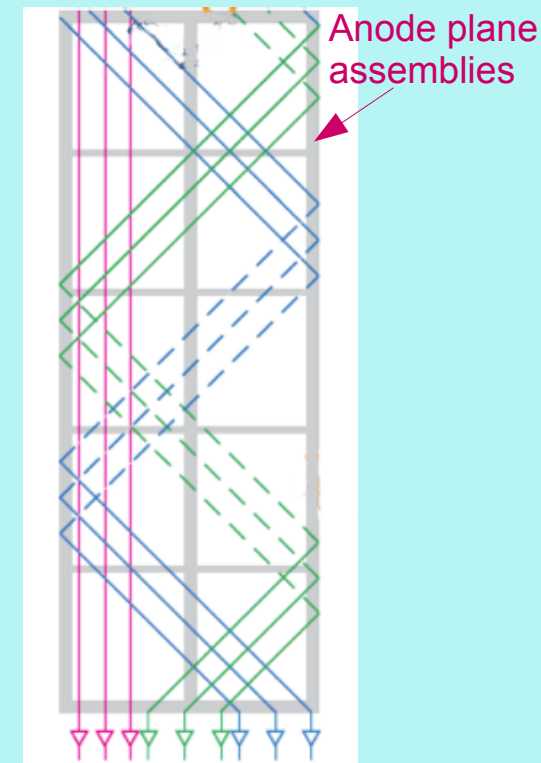
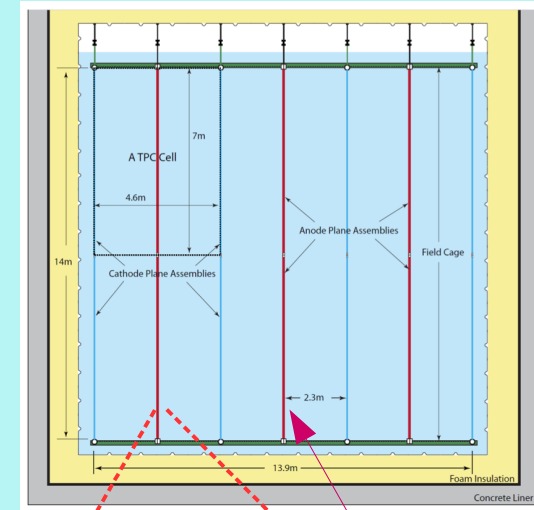
Alexei Talimonov, used w/o permission

Other complications

- Hit disambiguation

- DUNE TPCs have wrapped induction wires
 - See signals in two TPCs, and in many cases, multiple places within the same TPC
- Some LArSoft nomenclature:
 - “Wire”: a segment of a physical wire in an anode plane
 - A geometric concept
 - “Channel”: a readout channel connected to one or more “wires”
 - A DAQ concept

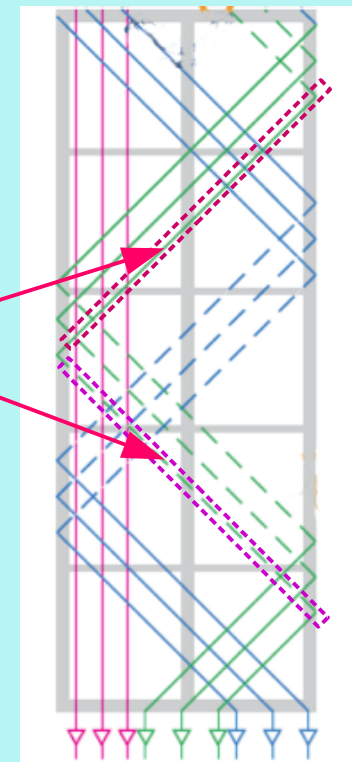
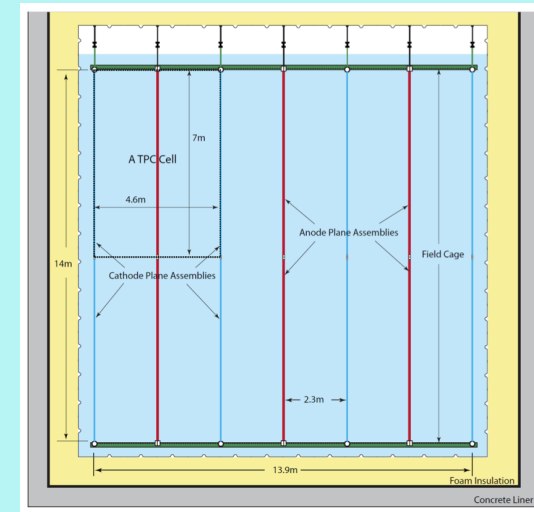
Sectional view of TPCs



Other complications

- Hit disambiguation

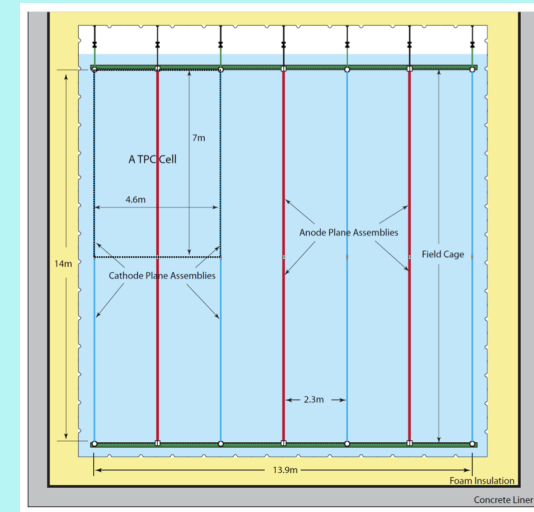
- DUNE TPCs have wrapped induction wires
 - See signals in two TPCs, and in many cases, multiple places within the same TPC
- Some LArSoft nomenclature:
 - “Wire”: a segment of a physical wire in an anode plane
 - A geometric concept
 - “Channel”: a readout channel connected to one or more “wires”
 - A DAQ concept



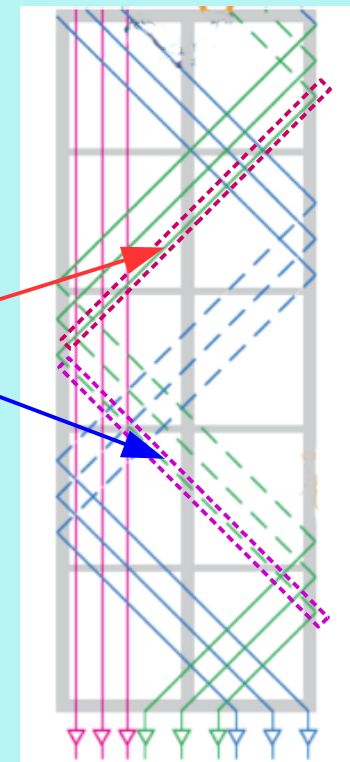
Other complications

- Hit disambiguation

- DUNE TPCs have wrapped induction wires
 - See signals in two TPCs, and in many cases, multiple places within the same TPC
- Some LArSoft nomenclature:
 - “Wire”: a segment of a physical wire in an anode plane
 - A geometric concept
 - “Channel”: a readout channel connected to one or more “wires”
 - A DAQ concept



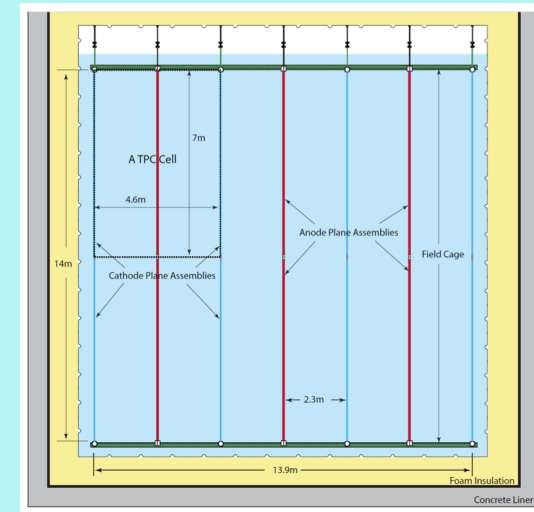
Two “wires”



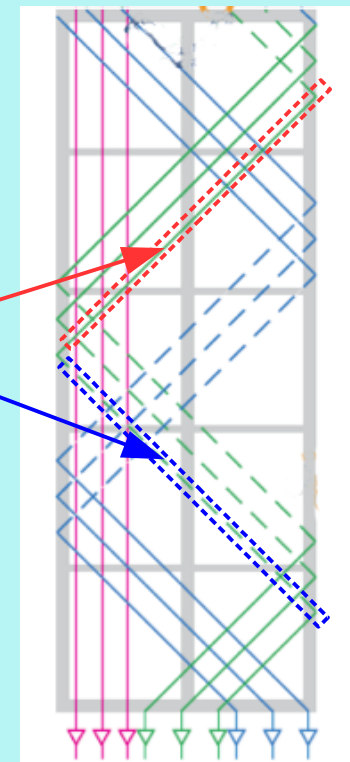
Other complications

- Hit disambiguation

- DUNE TPCs have wrapped induction wires
 - See signals in two TPCs, and in many cases, multiple places within the same TPC
- Introduce a disambiguation step to deal with this
 - Resolves the TPC ambiguity of each induction hit
 - Currently performed after hit-finding
 - Existing algorithms use timing information and neighboring activity



Two "wires"



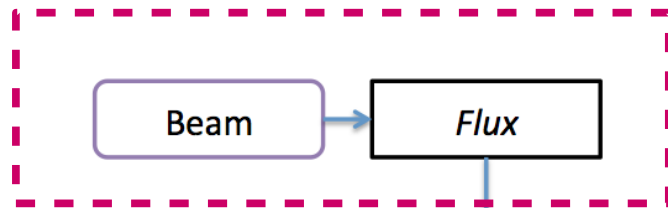
Dual phase TPC

- ProtoDUNE DP
 - Significant progress over the past year
 - See [talk by D. Stefan, R. Sulej from Wednesday](#)
 - A basic simulation and reconstruction workflow runs
 - Required some code changes, parameter tuning
 - But still using core, common LArSoft algorithms
 - Need to try other algorithms, workflows
 - A long list of improvements and change suggested

Detector simulation in LArSoft

Simulation workflow

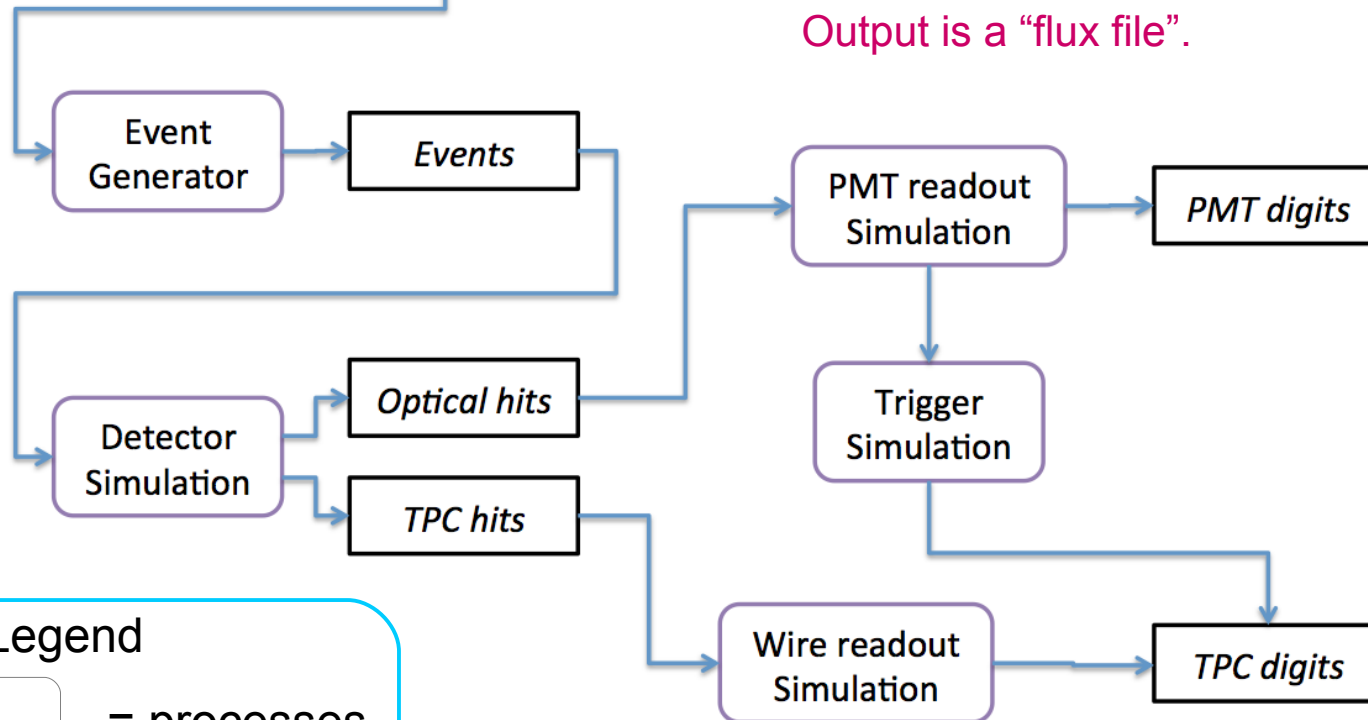
Three phases, typically run separately



Beam simulation

Momentum, spatial, angular distribution of neutrinos from target incident on detector

Output is a “flux file”.



Legend



= processes

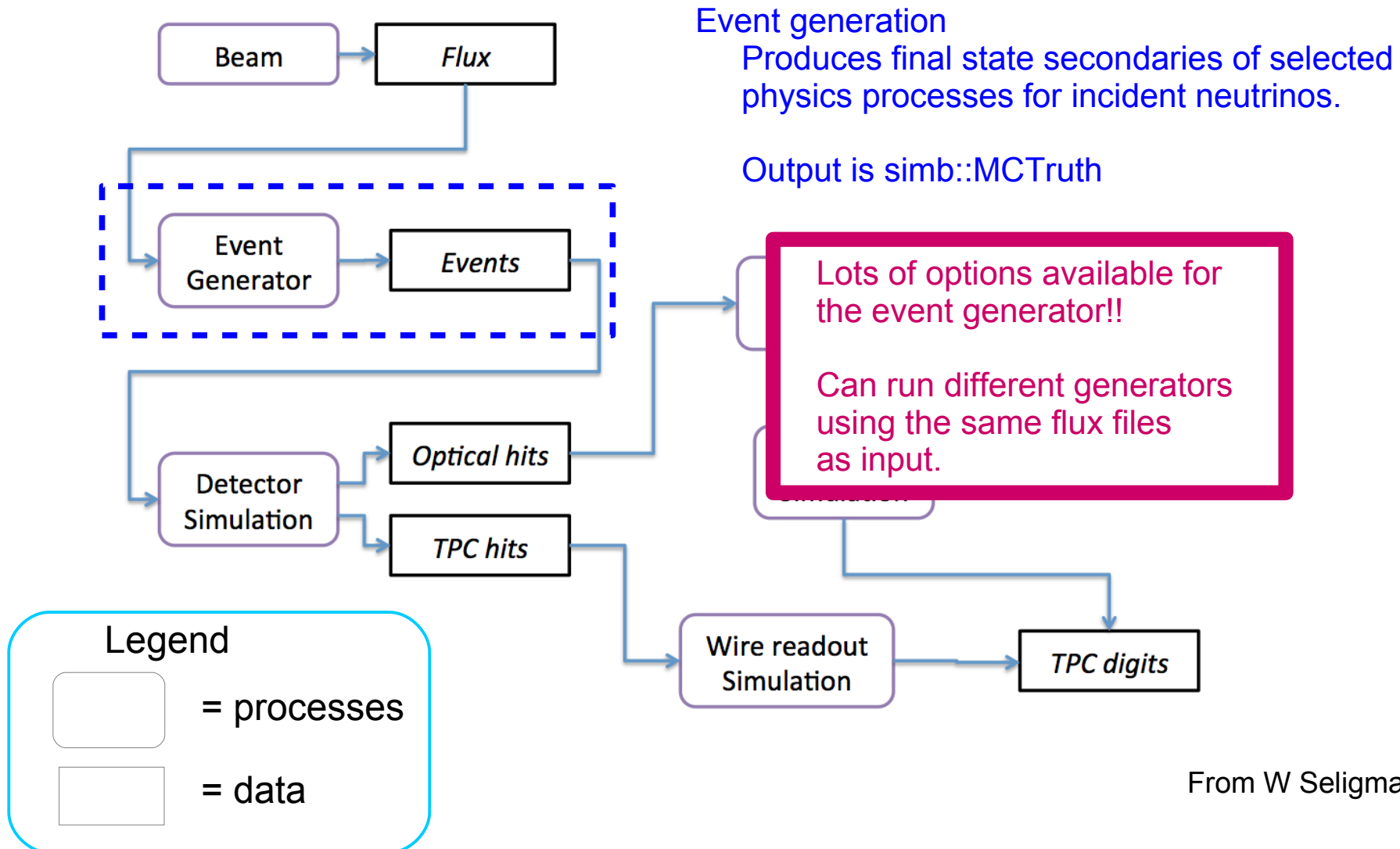


= data

From W Seligman

Simulation workflow

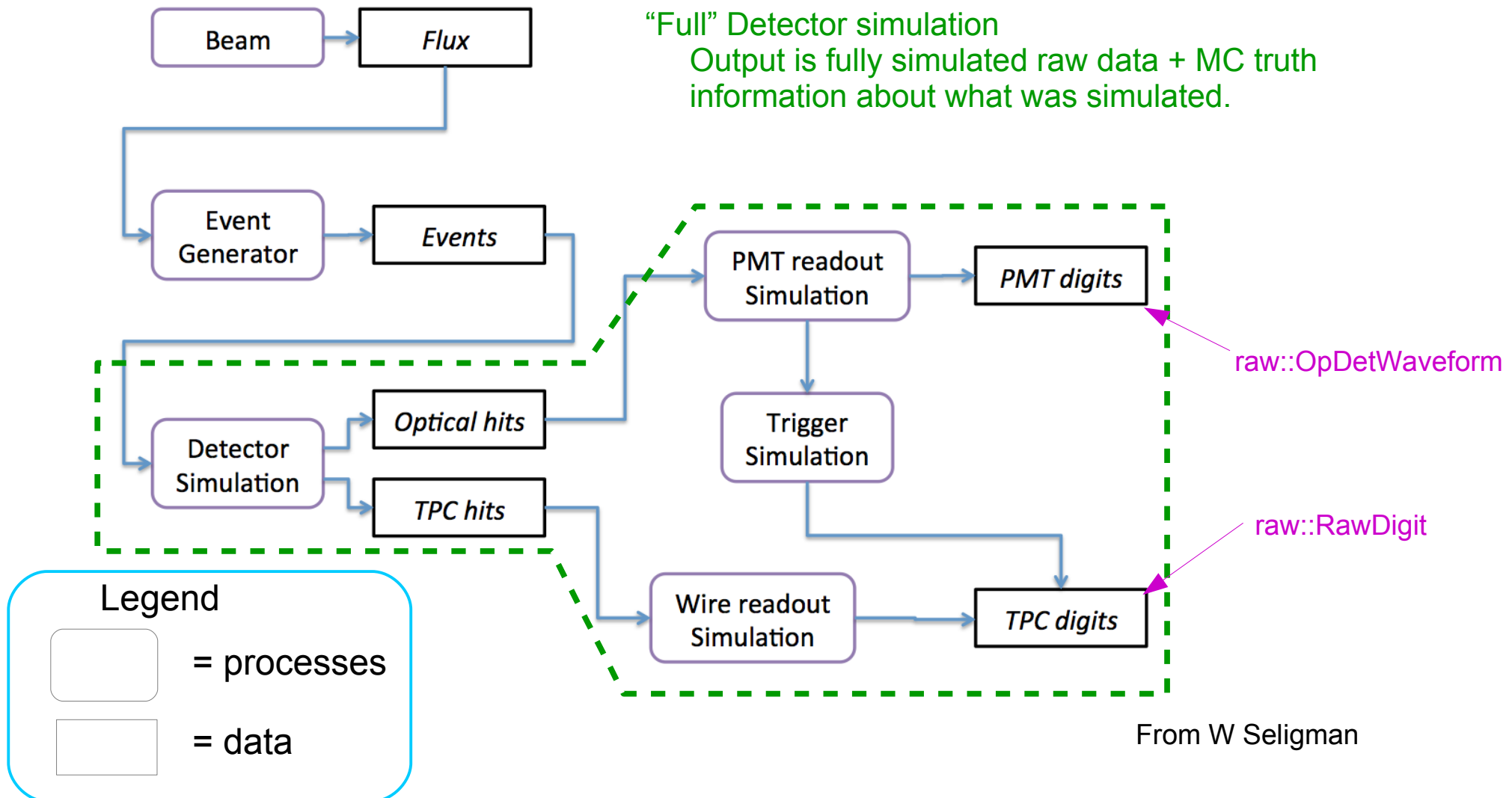
Three phases, typically run separately



From W Seligman

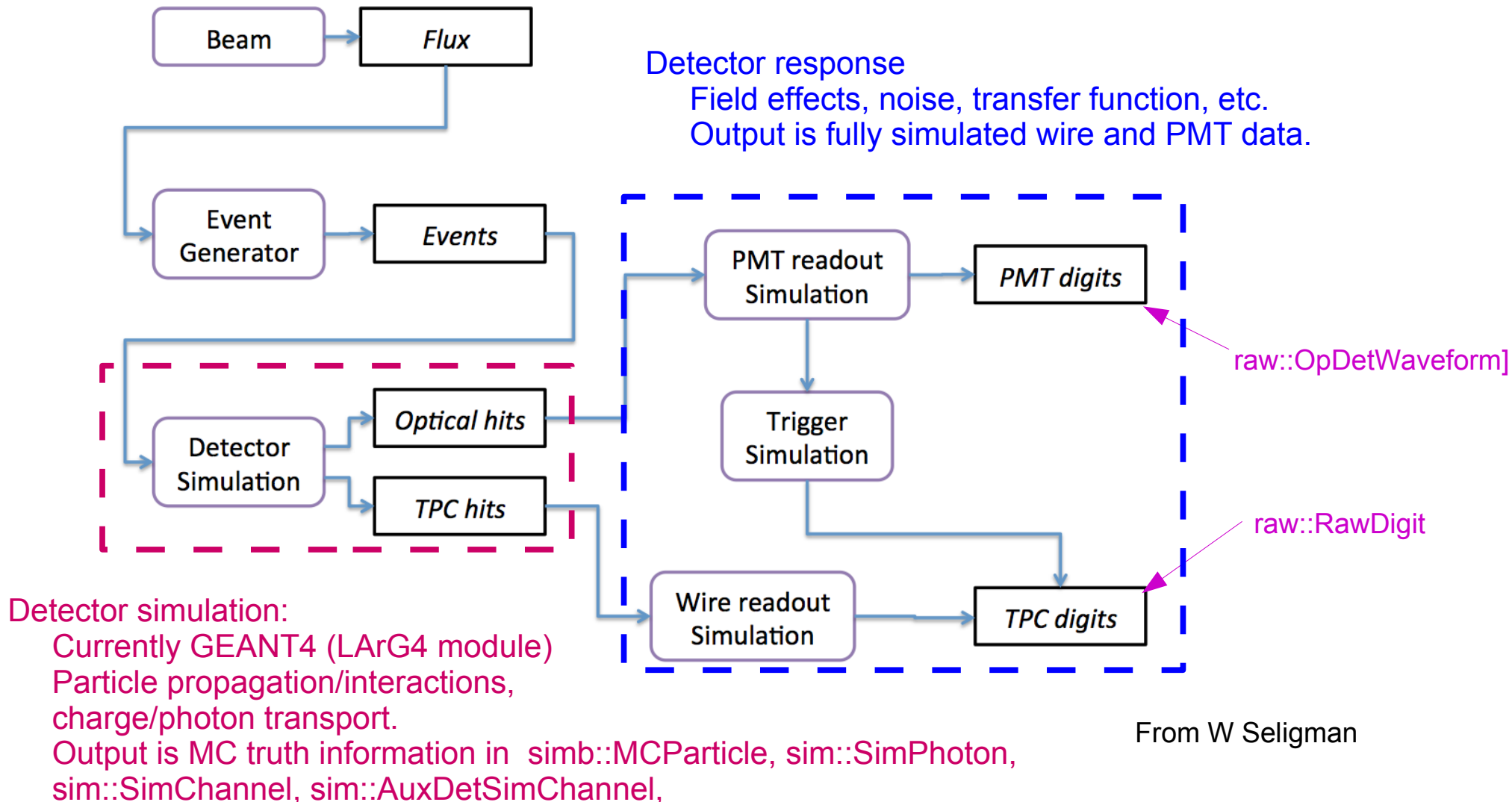
Simulation workflow

Three phases, typically run separately



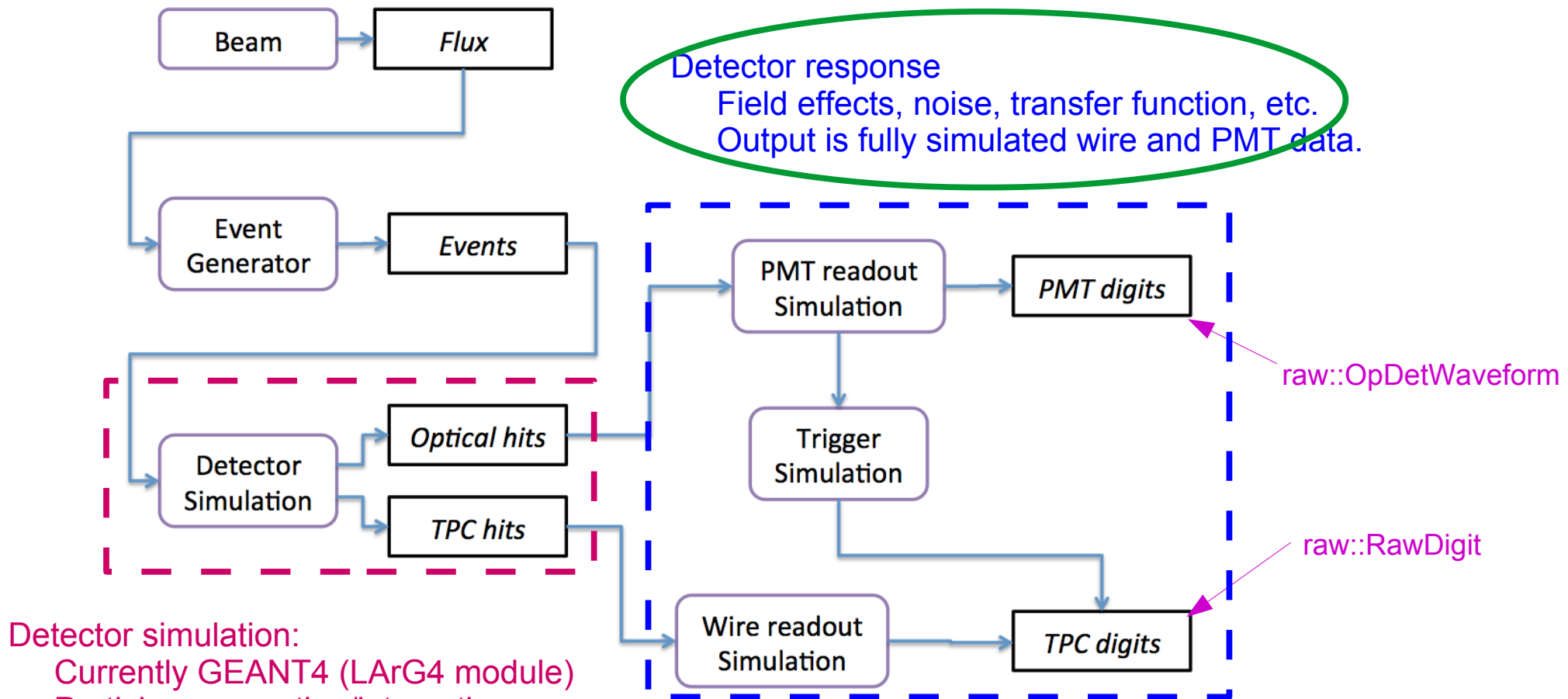
Simulation workflow

The full detector simulation includes two separable sub-phases



Simulation workflow

Most detect-specific customizations go into the detector response



Detector simulation:

Currently GEANT4 (LArG4 module)

Particle propagation/interactions,
charge/photon transport.

Output is MC truth information in `simb::MCParticle`, `sim::SimPhoton`,
`sim::SimChannel`, `sim::AuxDetSimChannel`,

From W Seligman

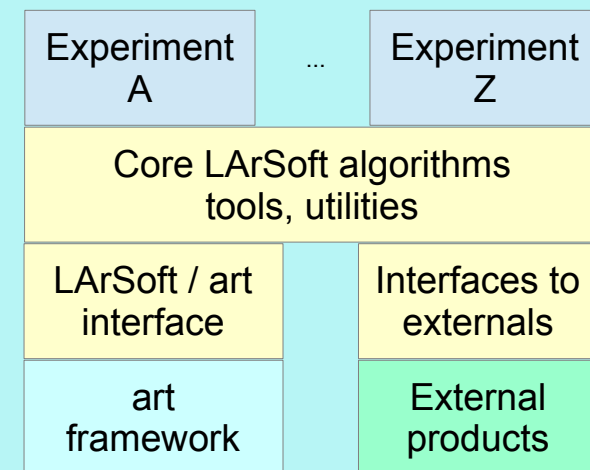
LArSoft design principles

LArSoft design principles and practices



- Detector interoperability
 - The most important design objective for the LArSoft project
 - Define (and use!!) common interfaces for accessing detector-specific configuration information and functionality
 - Applies to geometry, channel mappings, LAr properties, E-field map...

- Separation of framework and algorithm code
 - Encapsulate algorithms, configuration, tools and utilities into a layer that is independent of the art framework
 - Many benefits follow from this



General disclaimer:

In examining the code, you may note that only a portion currently adheres to these principles.

- An on-going architecture review project is intended to address this

Strongly encourage people to adopt these practices for all new code

LArSoft design principles and practices

- Use of standardized algorithm interfaces
 - Define standard interfaces for well-defined steps in the workflow to promote modularity, layering of algorithms
- Modularity
 - Build sophistication by applying algorithms in a layered, iterative structure
- Design / write testable units of code
 - Include unit and integration testing in the development process
 - Follow the practice of continuous integration
 - Perform automated, broad-scale testing at frequent intervals in order to catch unintended side-effects quickly

LArSoft design principles and practices

- Continuous integration
 - Automated tests run every time code is pushed to central git repositories
 - Code authors need to provide the relevant tests!!
 - See <http://larsoft.org/continuous-integration>
- Document code in the source files as it is written
 - See many files with **no comments at all** describing what the code does
 - At very least, need the have at the top of all header files:
 - the purpose of the file / code
 - pre-requisites and assumptions
 - Anything else people **need to know** in order to use it
- Document algorithms and services on <http://larsoft.org/add>
 - High-level description, the principal author, etc.

Using LArSoft

Supported platforms

See https://cdcv.sfnal.gov/redmine/projects/larsoft/wiki/_Supported_platforms_

- Scientific Linux
 - SLF6 (the reference system) + SLF7
 - Should work on any SL variant; Works on SLC6 (CERN), Redhat 6 (SLAC)
- Mac OSX
 - Mavericks and Yosemite
 - ups qualifiers d13:noifdh and d14:noifdh respectively
 - “Known to work” on El Capitan
 - Must disable SIP and install openssl
- Ubuntu
 - “Known to work” with Ubuntu14, demonstrated for 15 and 16
 - LArSoft team distributes installation tarballs for u14 (best effort only)

Installation instructions:

See links in release notes available at
https://cdcv.sfnal.gov/redmine/projects/larsoft/wiki/LArSoft_release_list

LArSoft code repositories

- Code lives in a set of git repositories hosted at Fermilab

larcore	Low level utilities
larcoreobj	Low level data products
larcoreal	Low level utilities
lardata	Data products
lardataobj	Data products
lardataalg	Low level algorithms
larevt	Low level algorithms that use data products
larsim	Simulation code
larreco	Primary reconstruction code
larana	Secondary reconstruction and analysis code
lareventdisplay	LArSoft-based event display
larpandora	LArSoft interface to Pandora
larexamples	Placeholder for examples

LArSoft code repositories

- Code lives in a set of git repositories hosted at Fermilab

larcore

Low level utilities

larcoreobi

Low level data products

- 1) All publicly accessible at <http://cdcv.s.fnal.gov/projects/<repository name>>
- 2) For read/write access: `ssh://p-<repository name>@cdcv.s.fnal.gov/cvs/projects/<repository name>>`
(requires valid kerberos ticket)

larevt

Low level algorithms that use data products

larsim

Simulation code

larreco

Primary reconstruction code

larana

Secondary reconstruction and analysis code

lareventdisplay

LArSoft-based event display

larpandora

LArSoft interface to Pandora

larexamples

Placeholder for examples

LArSoft products

- The build procedure creates and installs a **ups product** from the code in each repository

larcore	Low level utilities
larcoreobj	Low level data products
larcorealg	Low level utilities
lardata	Data products
lardataobj	Data products
lardataalg	Low level algorithms
larevt	Low level algorithms that use data products
larsim	Simulation code
larreco	Primary reconstruction code
larana	Secondary reconstruction and analysis code
lareventdisplay	LArSoft-based event display
larpandora	LArSoft interface to Pandora
larexamples	Placeholder for examples

Each product is self-contained,
aside from dependencies

LArSoft releases

- A **LArSoft release** is a consistent set of LArSoft products built from tagged versions of code in the repositories
 - Implicitly includes corresponding versions of all external dependencies used to build it
 - Each release of LArSoft has a release notes page on scisoft
 - <http://scisoft.fnal.gov/scisoft/bundles/larsoft/<version>/larsoft-<version>.html>
- **larsoft**
 - A larsoft umbrella product binds it all together to give it one version, one setup command
 - `setup larsoft v06_06_00 -q ...`
- **larsoft_data**
 - A ups product for large configuration files

larsoft v04.16.00	
Product	Version
larcore	v04.13.00
lardata	v04.11.00
larevt	v04.08.06
larsim	v04.08.03
larreco	v04.12.00
larana	v04.08.00
lareventdisplay	v04.06.00
larpandora	v04.04.16
larexamples	v04.04.16
larsoft_data	v0.04.00

...

LArSoft releases

- Two types of releases
 - Integration
 - Created weekly or on demand for special purposes
 - Contents approved at Coordination Meetings
 - Head of develop + additional branches approved at a CM or via email
 - May be removed without notice after about a month
 - In practice, we announce our intentions in advance
 - Production
 - Any release designated as “production” by an experiment
 - Created on demand (but usually on the weekly schedule)
 - Contents approved by the experiment declaring production
 - Typically also coordinated through the CM to keep other experiments informed
 - Production releases are retained on disk indefinitely
- List of all available tagged releases
 - https://cdcvs.fnal.gov/redmine/projects/larsoft/wiki/LArSoft_release_list

How to set up and run art/LArSoft

- First point to note

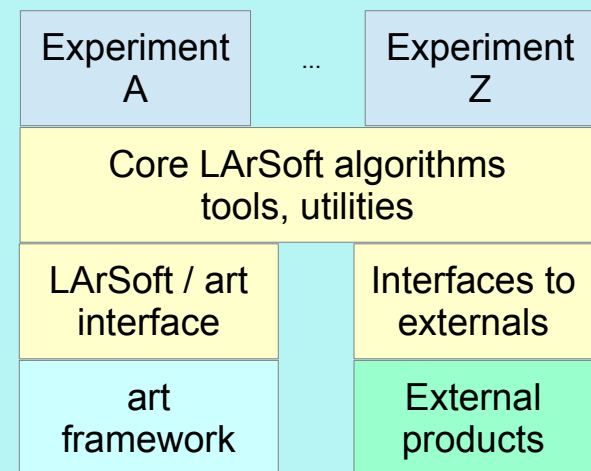
- LArSoft is designed to be run by experiments

- Need detector-specific parts to run it
- So start with the code of your experiment

DUNE	dunetpc
LArIAT	lariatsoft
MicroBooNE	uboonecode
SBND	sbndcode

The setup procedures for each are different
so refer to the relevant setup instructions

- For DUNE, https://cdcvs.fnal.gov/redmine/projects/dunetpc/wiki/_Tutorial_



- Second point to note

- Do not need a “working area” to run LArSoft. Just need to set up the appropriate products + a fcl file

How to set up and run art/LArSoft

- The most simple scenario: run from a tagged LArSoft release
 - First, set up the working environment:

```
# Set up ups
source <ups location>/setup
#
# Set up the working environment
# for your experiment
<the setup procedure for your experiment here>

# Set up a LArSoft release
setup larsoft v06_06_00 -q e10:<prof|debug>
```

- In most cases, experiment-specific setup scripts will include all of the above
- Note that setting up for development requires additional steps
- Now run art (the LArSoft version is called `lar`)

```
# List art command-line options
lar --help
#
# Now run LArSoft
#
lar -c <some fcl file>.fcl [-i <input file>]
```

That's it! ...if you have a fcl file and have no code to change

Setting up and running LArSoft as a developer

Use this basic procedure to modify code, including your own art-based analysis code

Start with the same setup procedure from the previous page

Note that **mr**b**** is the primary build tool used by LArSoft

mrb** -help** to list commands
mrb** <command> --help** for more information

```
# Create working area
mkdir workdir
cd workdir
mrb newDev -v v06_06_00 -q e10:prof

# Now perform local setup
source localProducts_larsoft_v06_06_00_e10_prof/setup

# Move to source area and check out code
cd srcs
mrb g <repository name>      # or mrb gitCheckout ...

# Develop code
cd <repository name>/...

# Set up build environment
cd $MRB_BUILDDIR
mrbsetenv

# Build and install ('install' will actually do both)
mrb b -j<N>                  # or mrb build; N = # cores to use
mrb I -j <N>                  # or mrb install

# Set up newly built code
mrbslp                       # 'slp' = setup local products

# Run as before
lar -c ...
```

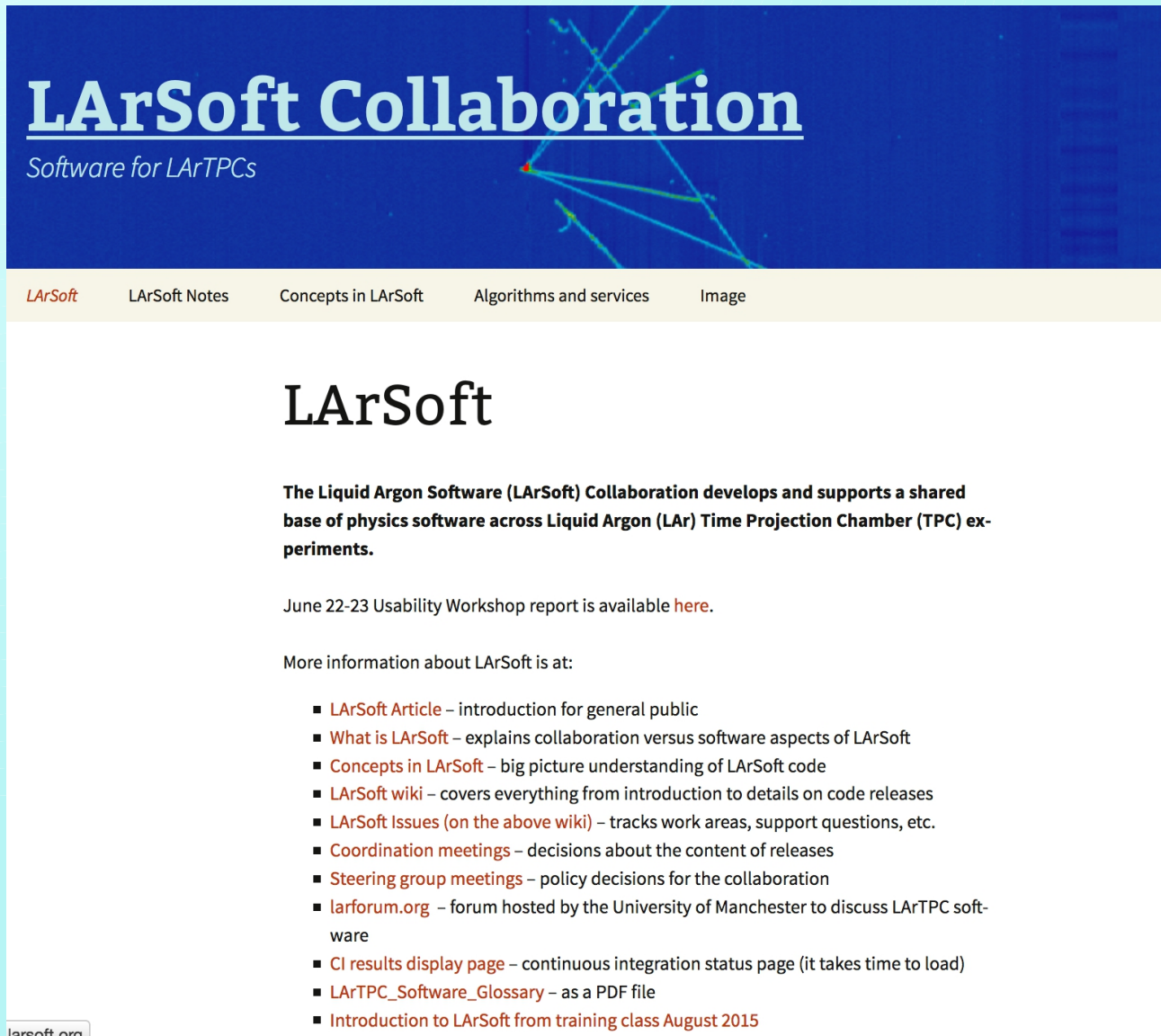
Getting LArSoft to work with a new detector

- LArSoft is really a toolkit
 - It requires a certain amount of detector-specific information and plug-in functionality in order to work
- The minimum needed to run LArSoft for a new detector
 - Define the geometry for the new detector in a GDML file
 - Customize E-field, drift velocity, readout parameters, etc, as needed
 - Customize digitization for simulation, as needed
 - Write a fcl file
 - `lar -c sim_new_det.fcl → simulated data; lar -c <reco...>.fcl → results!!`

...A bit over-simplified, but this is basically what happens

Resources

larsoft.org



LArSoft Collaboration
Software for LArTPCs

[LArSoft](#) [LArSoft Notes](#) [Concepts in LArSoft](#) [Algorithms and services](#) [Image](#)

LArSoft

The Liquid Argon Software (LArSoft) Collaboration develops and supports a shared base of physics software across Liquid Argon (LAr) Time Projection Chamber (TPC) experiments.

June 22-23 Usability Workshop report is available [here](#).

More information about LArSoft is at:

- [LArSoft Article](#) – introduction for general public
- [What is LArSoft](#) – explains collaboration versus software aspects of LArSoft
- [Concepts in LArSoft](#) – big picture understanding of LArSoft code
- [LArSoft wiki](#) – covers everything from introduction to details on code releases
- [LArSoft Issues \(on the above wiki\)](#) – tracks work areas, support questions, etc.
- [Coordination meetings](#) – decisions about the content of releases
- [Steering group meetings](#) – policy decisions for the collaboration
- [larforum.org](#) – forum hosted by the University of Manchester to discuss LArTPC software
- [CI results display page](#) – continuous integration status page (it takes time to load)
- [LArTPC_Software_Glossary](#) – as a PDF file
- [Introduction to LArSoft from training class August 2015](#)

larsoft.org

The public facing home page for the LArSoft Collaboration

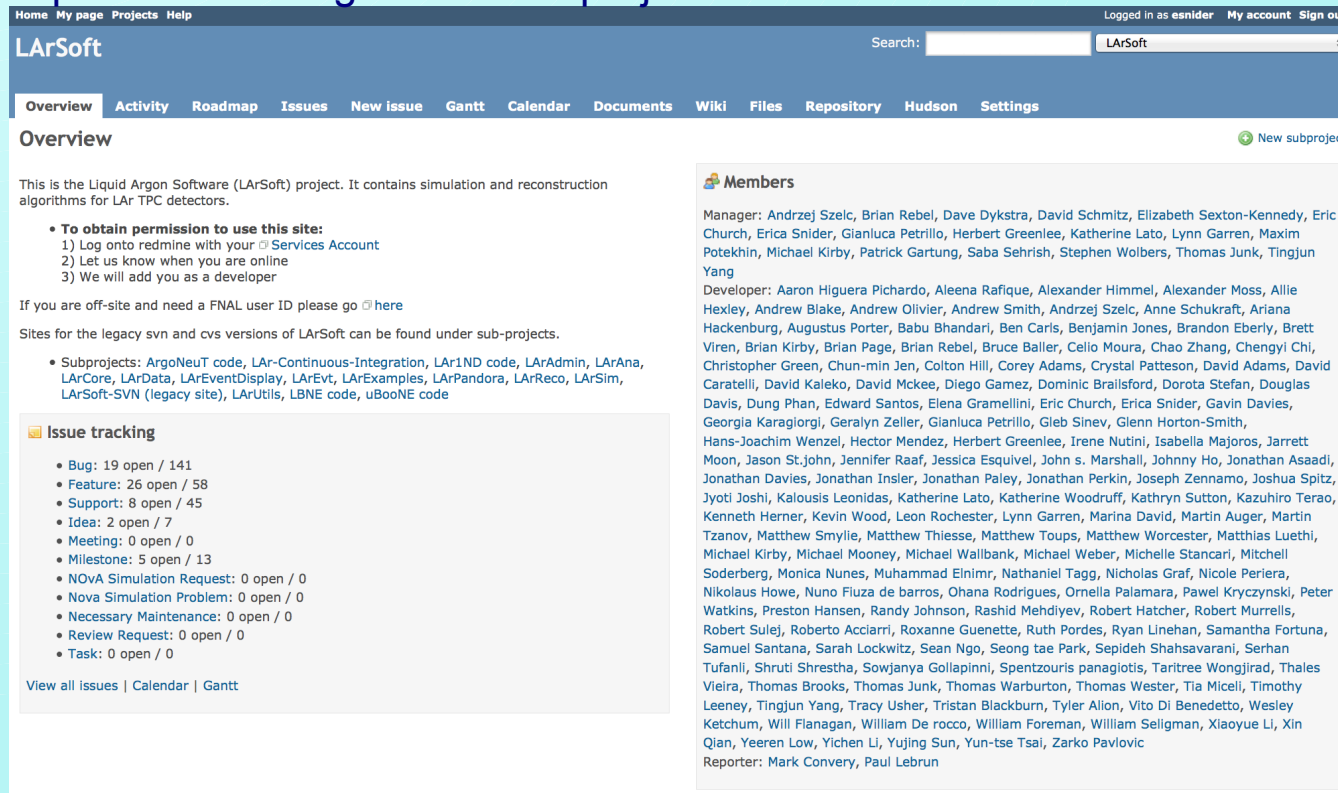
Contains introductory information + links to further information and resources

Tabs across the top link to different types of content

LArSoft Redmine site

Redmine sites are called “projects”

<https://cdcvcs.fnal.gov/redmine/projects/larsoft>



The screenshot shows the LArSoft Redmine project home page. At the top, there is a navigation bar with links: Home, My page, Projects, Help. On the right, it says 'Logged in as esnider' with links for 'My account' and 'Sign out'. Below the navigation bar is a search bar and a dropdown menu set to 'LArSoft'. A secondary navigation bar contains tabs: Overview, Activity, Roadmap, Issues, New issue, Gantt, Calendar, Documents, Wiki, Files, Repository, Hudson, Settings. The 'Overview' tab is selected.

Overview

This is the Liquid Argon Software (LArSoft) project. It contains simulation and reconstruction algorithms for LAr TPC detectors.

- **To obtain permission to use this site:**
 - 1) Log onto redmine with your [Services Account](#)
 - 2) Let us know when you are online
 - 3) We will add you as a developer

If you are off-site and need a FNAL user ID please go [here](#)

Sites for the legacy svn and cvs versions of LArSoft can be found under sub-projects.

- Subprojects: ArgoNeUT code, LAr-Continuous-Integration, LAr1ND code, LArAdmin, LArAna, LArCore, LArData, LArEventDisplay, LArEvt, LArExamples, LArPandora, LArReco, LArSim, LArSoft-SVN (legacy site), LArUtils, LBNE code, uBooNE code

Issue tracking

- Bug: 19 open / 141
- Feature: 26 open / 58
- Support: 8 open / 45
- Idea: 2 open / 7
- Meeting: 0 open / 0
- Milestone: 5 open / 13
- NOvA Simulation Request: 0 open / 0
- Nova Simulation Problem: 0 open / 0
- Necessary Maintenance: 0 open / 0
- Review Request: 0 open / 0
- Task: 0 open / 0

[View all issues](#) | [Calendar](#) | [Gantt](#)

Members

Manager: Andrzej Szelc, Brian Rebel, Dave Dykstra, David Schmitz, Elizabeth Sexton-Kennedy, Eric Church, Erica Snider, Gianluca Petrillo, Herbert Greenlee, Katherine Lato, Lynn Garren, Maxim Potekhin, Michael Kirby, Patrick Gartung, Saba Sehrish, Stephen Wolbers, Thomas Junk, Tingjun Yang

Developer: Aaron Higuera Pichardo, Aleena Rafique, Alexander Himmel, Alexander Moss, Allie Hexley, Andrew Blake, Andrew Olivier, Andrew Smith, Andrzej Szelc, Anne Schukraft, Ariana Hackenburg, Augustus Porter, Babu Bhandari, Ben Carls, Benjamin Jones, Brandon Eberly, Brett Viren, Brian Kirby, Brian Page, Brian Rebel, Bruce Baller, Cello Moura, Chao Zhang, Chengyi Chi, Christopher Green, Chun-min Jen, Colton Hill, Corey Adams, Crystal Patteson, David Adams, David Caratelli, David Kaleko, David McKee, Diego Gamez, Dominic Brallsford, Dorota Stefan, Douglas Davis, Dung Phan, Edward Santos, Elena Gramellini, Eric Church, Erica Snider, Gavin Davies, Georgia Karagiorgi, Geralyn Zeller, Gianluca Petrillo, Gleb Sinev, Glenn Horton-Smith, Hans-Joachim Wenzel, Hector Mendez, Herbert Greenlee, Irene Nutini, Isabella Majoros, Jarrett Moon, Jason St.John, Jennifer Raaf, Jessica Esquivel, John s. Marshall, Johnny Ho, Jonathan Asaadi, Jonathan Davies, Jonathan Insler, Jonathan Paley, Jonathan Perkin, Joseph Zennamo, Joshua Spitz, Jyoti Joshi, Kalousis Leonidas, Katherine Lato, Katherine Woodruff, Kathryn Sutton, Kazuhiro Terao, Kenneth Herner, Kevin Wood, Leon Rochester, Lynn Garren, Marina David, Martin Auger, Martin Tzanov, Matthew Smylie, Matthew Thiesse, Matthew Toups, Matthew Worcester, Matthias Luethi, Michael Kirby, Michael Mooney, Michael Wallbank, Michael Weber, Michelle Stancari, Mitchell Soderberg, Monica Nunes, Muhammad Elinimr, Nathaniel Tagg, Nicholas Graf, Nicole Periera, Nikolaus Howe, Nuno Fluzza de Barros, Ohana Rodrigues, Ornella Palamara, Pawel Kryczynski, Peter Watkins, Preston Hansen, Randy Johnson, Rashid Mehdiyev, Robert Hatcher, Robert Murrells, Robert Sulej, Roberto Acciarri, Roxanne Guenette, Ruth Pordes, Ryan Linehan, Samantha Fortuna, Samuel Santana, Sarah Lockwitz, Sean Ngo, Seong tae Park, Sepideh Shahsavarani, Serhan Tufanli, Shruti Shrestha, Sowjanya Gollapinni, Spentzouris panagiotis, Taritree Wongjirad, Thales Vieira, Thomas Brooks, Thomas Junk, Thomas Warburton, Thomas Wester, Tia Miceli, Timothy Leeney, Tingjun Yang, Tracy Usher, Tristan Blackburn, Tyler Alton, Vito Di Benedetto, Wesley Ketchum, Will Flanagan, William De rocco, William Foreman, William Seligman, Xiaoyue Li, Xin Qian, Yeeren Low, Yichen Li, Yujing Sun, Yun-tse Tsai, Zarko Pavlovic

Reporter: Mark Convery, Paul Lebrun

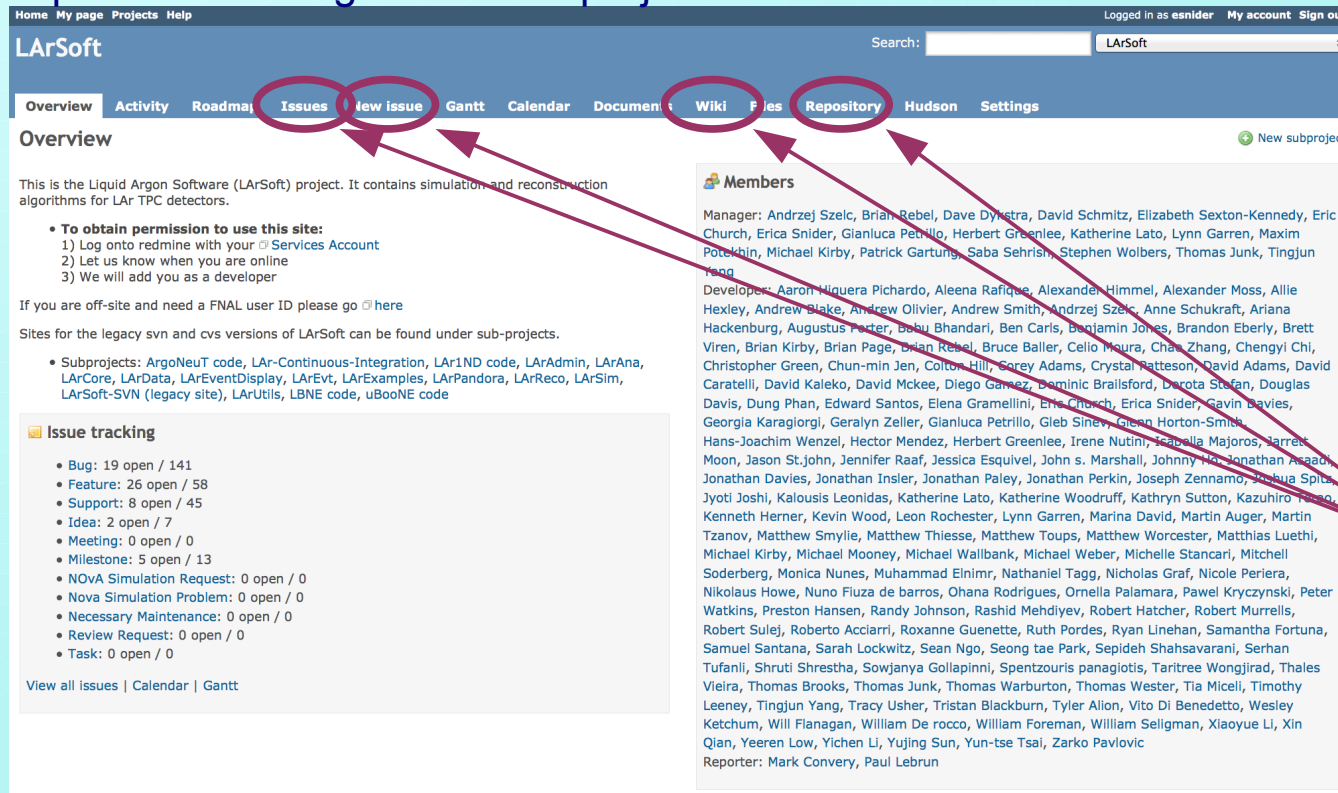
This is the home page for the LArSoft Redmine project

Tabs across the top link to different types of content

LArSoft Redmine site

Redmine sites are called “projects”

<https://cdcvcs.fnal.gov/redmine/projects/larsoft>



Home My page Projects Help

Logged in as esnider My account Sign out

Search: LArSoft

Overview Activity Roadmap **Issues** **New issue** Gantt Calendar Documents **Wiki** **Files** **Repository** Hudson Settings

Overview

This is the Liquid Argon Software (LArSoft) project. It contains simulation and reconstruction algorithms for LAr TPC detectors.

- To obtain permission to use this site:**
 - 1) Log onto redmine with your [Services Account](#)
 - 2) Let us know when you are online
 - 3) We will add you as a developer

If you are off-site and need a FNAL user ID please go [here](#)

Sites for the legacy svn and cvs versions of LArSoft can be found under sub-projects.

- Subprojects: ArgoNeUT code, LAr-Continuous-Integration, LAr1ND code, LArAdmin, LArAna, LArCore, LArData, LArEventDisplay, LArEvt, LArExamples, LArPandora, LArReco, LArSim, LArSoft-SVN (legacy site), LArUtils, LBNE code, uBooNE code

Issue tracking

- Bug: 19 open / 141
- Feature: 26 open / 58
- Support: 8 open / 45
- Idea: 2 open / 7
- Meeting: 0 open / 0
- Milestone: 5 open / 13
- NOvA Simulation Request: 0 open / 0
- Nova Simulation Problem: 0 open / 0
- Necessary Maintenance: 0 open / 0
- Review Request: 0 open / 0
- Task: 0 open / 0

View all issues | Calendar | Gantt

Members

Manager: Andrzej Szelc, Brian Rebel, Dave Dynstra, David Schmitz, Elizabeth Sexton-Kennedy, Eric Church, Erica Snider, Gianluca Petrillo, Herbert Greenlee, Katherine Lato, Lynn Garren, Maxim Potekhin, Michael Kirby, Patrick Gartung, Saba Sehrish, Stephen Wolbers, Thomas Junk, Tingjun Yang

Developer: Aaron Miquera Pichardo, Aleena Rafique, Alexander Himmel, Alexander Moss, Allie Hexley, Andrew Blake, Andrew Olivier, Andrew Smith, Andrzej Szelc, Anne Schukraft, Ariana Hackenburg, Augustus Peder, Babu Bhandari, Ben Carls, Benjamin Jones, Brandon Eberly, Brett Viren, Brian Kirby, Brian Page, Brian Rebel, Bruce Baller, Cello Moura, Chen Zhang, Chengyi Chi, Christopher Green, Chun-min Jen, Colton Hill, Corey Adams, Crystal Matteson, David Adams, David Caratelli, David Kaleko, David McKee, Diego Gamez, Dominic Brailsford, Dorota Stefan, Douglas Davis, Dung Phan, Edward Santos, Elena Gramellini, Eric Church, Erica Snider, Gavin Davies, Georgia Karagiorgi, GERALYN Zeller, Gianluca Petrillo, Gleb Sinev, Glenn Horton-Smith, Hans-Joachim Wenzel, Hector Mendez, Herbert Greenlee, Irene Nutini, Isabella Majoros, Jarrett Moon, Jason St. John, Jennifer Raaf, Jessica Esquivel, John s. Marshall, Johnny Ho, Jonathan Asaad, Jonathan Davies, Jonathan Insler, Jonathan Paley, Jonathan Perkin, Joseph Zennaro, Joshua Spica, Jyoti Joshi, Kalousis Leonidas, Katherine Lato, Katherine Woodruff, Kathryn Sutton, Kazuhiro Terao, Kenneth Herner, Kevin Wood, Leon Rochester, Lynn Garren, Marina David, Martin Auger, Martin Tzanov, Matthew Smylie, Matthew Thiesse, Matthew Toups, Matthew Worcester, Matthias Luethi, Michael Kirby, Michael Mooney, Michael Wallbank, Michael Weber, Michelle Stancari, Mitchell Soderberg, Monica Nunes, Muhammad Elnimr, Nathaniel Tagg, Nicholas Graf, Nicole Periera, Nikolaus Howe, Nuno Fluzza de Barros, Ohana Rodrigues, Ornella Palamara, Pawel Kryczynski, Peter Watkins, Preston Hansen, Randy Johnson, Rashid Mehdiyev, Robert Hatcher, Robert Murrells, Robert Sulej, Roberto Acciarri, Roxanne Guenette, Ruth Pordes, Ryan Linehan, Samantha Fortuna, Samuel Santana, Sarah Lockwitz, Sean Ngo, Seong tae Park, Sepideh Shahsavaran, Serhan Tufanli, Shruti Shrestha, Sowjanya Gollapinni, Spentzouris panagiotis, Taritree Wongjirad, Thales Vieira, Thomas Brooks, Thomas Junk, Thomas Warburton, Thomas Wester, Tia Miceli, Timothy Leeney, Tingjun Yang, Tracy Usher, Tristan Blackburn, Tyler Alton, Vito Di Benedetto, Wesley Ketchum, Will Flanagan, William De rocco, William Foreman, William Seligman, Xiaoyue Li, Xin Qian, Yeeen Low, Yichen Li, Yujing Sun, Yun-tse Tsai, Zarko Pavlovic

Reporter: Mark Convery, Paul Lebrun

This is the home page for the LArSoft Redmine project

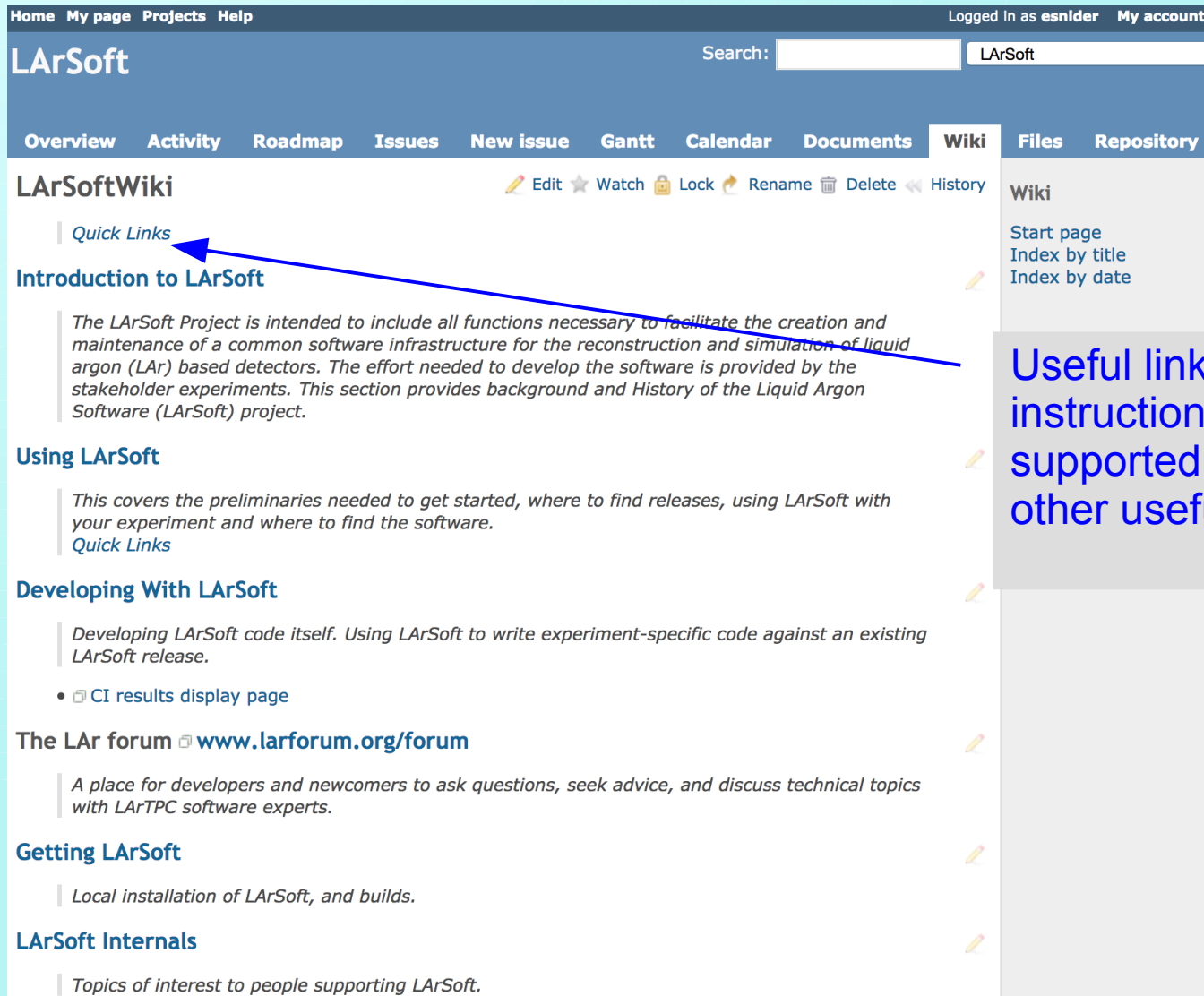
Tabs across the top link to different types of content

The most useful tabs:

- Wiki
- Issues
- New Issues
- Repository

LArSoft wiki

<https://cdcvcs.fnal.gov/redmine/projects/larsoft/wiki>



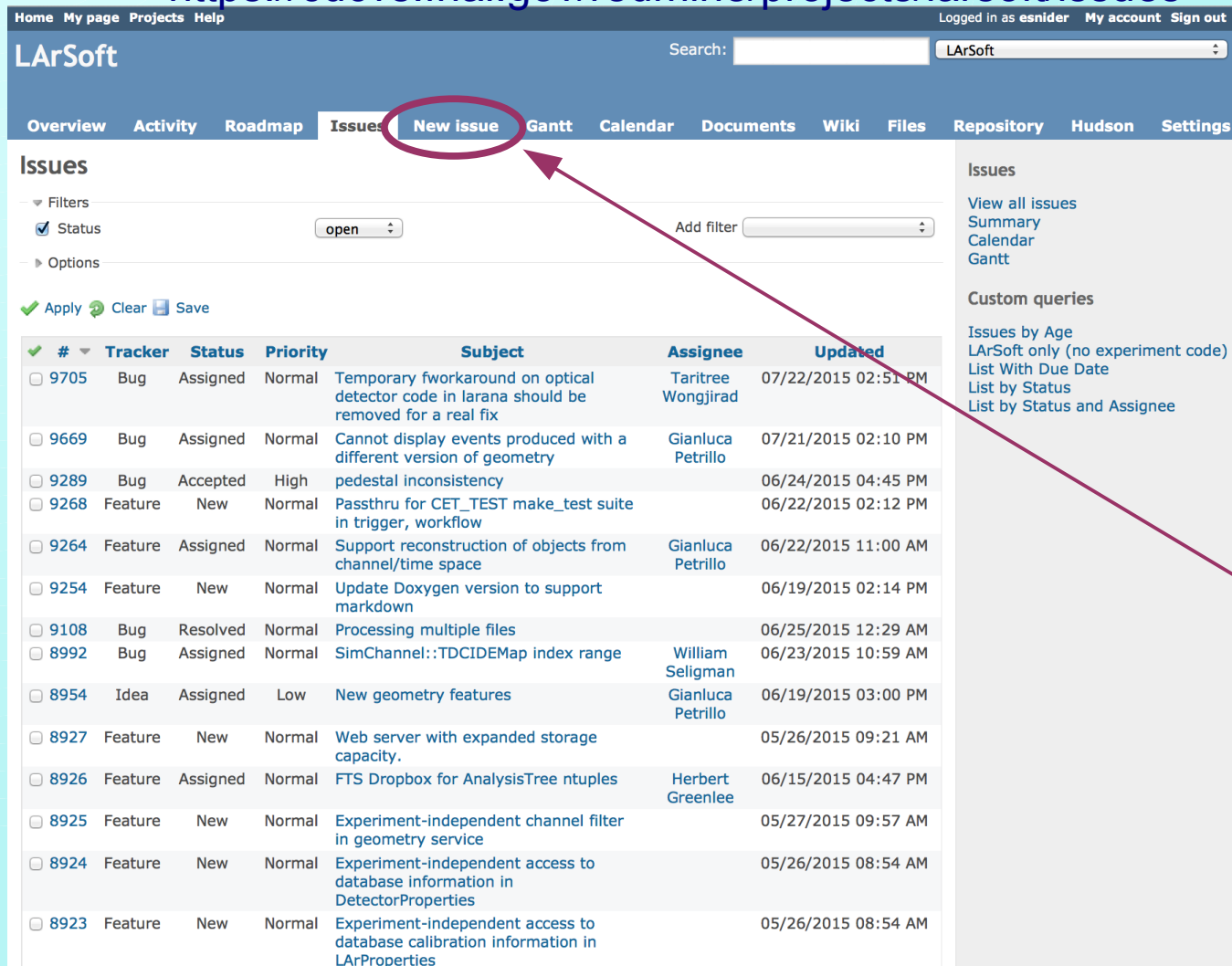
The screenshot shows the LArSoft wiki interface. At the top, there's a navigation bar with links: Home, My page, Projects, Help. A search bar is present with the text 'LArSoft'. Below the navigation bar, there's a tabbed interface with tabs: Overview, Activity, Roadmap, Issues, New issue, Gantt, Calendar, Documents, Wiki (selected), Files, and Repository. The main content area is titled 'LArSoftWiki' and includes a 'Quick Links' section with a blue arrow pointing to the 'Introduction to LArSoft' page. The 'Introduction to LArSoft' page contains a paragraph about the project's purpose. Below this, there are sections for 'Using LArSoft', 'Developing With LArSoft', 'The LAr forum', 'Getting LArSoft', and 'LArSoft Internals'. A blue box on the right side of the screenshot contains text about useful links to getting started instructions, list of releases, supported platforms and other useful information.

General information and documentation

Useful links to getting started instructions, list of releases, supported platforms and other useful information.

LArSoft issue tracker

<https://cdcvns.fnal.gov/redmine/projects/larsoft/issues>



Home My page Projects Help Logged in as esnider My account Sign out

LArSoft Search: LArSoft

Overview Activity Roadmap **Issues** **New issue** Gantt Calendar Documents Wiki Files Repository Hudson Settings

Issues

Filters

☒ Status open Add filter

Options

Apply Clear Save

#	Tracker	Status	Priority	Subject	Assignee	Updated
9705	Bug	Assigned	Normal	Temporary fworkaround on optical detector code in larana should be removed for a real fix	Taritree Wongjirad	07/22/2015 02:51 PM
9669	Bug	Assigned	Normal	Cannot display events produced with a different version of geometry	Gianluca Petrillo	07/21/2015 02:10 PM
9289	Bug	Accepted	High	pedestal inconsistency		06/24/2015 04:45 PM
9268	Feature	New	Normal	Passthru for CET_TEST make_test suite in trigger, workflow		06/22/2015 02:12 PM
9264	Feature	Assigned	Normal	Support reconstruction of objects from channel/time space	Gianluca Petrillo	06/22/2015 11:00 AM
9254	Feature	New	Normal	Update Doxygen version to support markdown		06/19/2015 02:14 PM
9108	Bug	Resolved	Normal	Processing multiple files		06/25/2015 12:29 AM
8992	Bug	Assigned	Normal	SimChannel::TDCIDEMap index range	William Seligman	06/23/2015 10:59 AM
8954	Idea	Assigned	Low	New geometry features	Gianluca Petrillo	06/19/2015 03:00 PM
8927	Feature	New	Normal	Web server with expanded storage capacity.		05/26/2015 09:21 AM
8926	Feature	Assigned	Normal	FTS Dropbox for AnalysisTree ntuples	Herbert Greenlee	06/15/2015 04:47 PM
8925	Feature	New	Normal	Experiment-independent channel filter in geometry service		05/27/2015 09:57 AM
8924	Feature	New	Normal	Experiment-independent access to database information in DetectorProperties		05/26/2015 08:54 AM
8923	Feature	New	Normal	Experiment-independent access to database calibration information in LArProperties		05/26/2015 08:54 AM

Issues

View all issues
Summary
Calendar
Gantt

Custom queries

Issues by Age
LArSoft only (no experiment code)
List With Due Date
List by Status
List by Status and Assignee

We track bugs, problems with LArSoft-related infrastructure, requests for support and new features, questions...

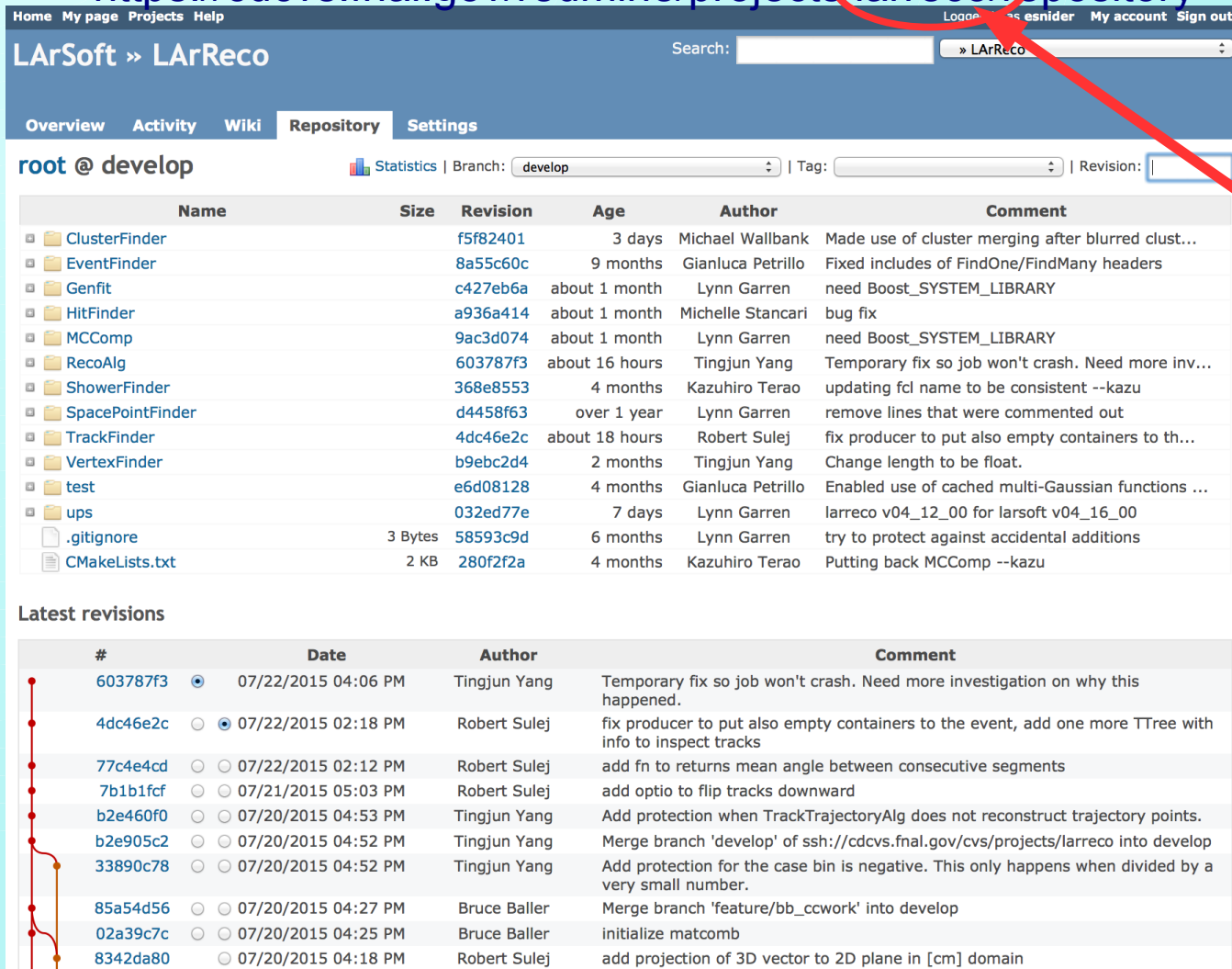
Open a new ticket using the “New Issue” tab if you have any of the above

Create a new issue using this tab.

Must be logged into Redmine using your Fermilab **services account** and password

LArSoft Redmine code browser ...


<https://cdcvcs.fnal.gov/redmine/projects/larreco/repository>



Home My page Projects Help Login esnider My account Sign out

LArSoft » LArReco Search: » LArReco

Overview Activity Wiki **Repository** Settings

root @ develop  Statistics | Branch: | Tag: | Revision:

Name	Size	Revision	Age	Author	Comment
ClusterFinder		f5f82401	3 days	Michael Wallbank	Made use of cluster merging after blurred clust...
EventFinder		8a55c60c	9 months	Gianluca Petrillo	Fixed includes of FindOne/FindMany headers
Genfit		c427eb6a	about 1 month	Lynn Garren	need Boost_SYSTEM_LIBRARY
HitFinder		a936a414	about 1 month	Michelle Stancari	bug fix
MCComp		9ac3d074	about 1 month	Lynn Garren	need Boost_SYSTEM_LIBRARY
RecoAlg		603787f3	about 16 hours	Tingjun Yang	Temporary fix so job won't crash. Need more inv...
ShowerFinder		368e8553	4 months	Kazuhiro Terao	updating fcl name to be consistent --kazu
SpacePointFinder		d4458f63	over 1 year	Lynn Garren	remove lines that were commented out
TrackFinder		4dc46e2c	about 18 hours	Robert Sulej	fix producer to put also empty containers to th...
VertexFinder		b9ebc2d4	2 months	Tingjun Yang	Change length to be float.
test		e6d08128	4 months	Gianluca Petrillo	Enabled use of cached multi-Gaussian functions ...
ups		032ed77e	7 days	Lynn Garren	larreco v04_12_00 for larsoft v04_16_00
.gitignore	3 Bytes	58593c9d	6 months	Lynn Garren	try to protect against accidental additions
CMakeLists.txt	2 KB	280f2f2a	4 months	Kazuhiro Terao	Putting back MCComp --kazu

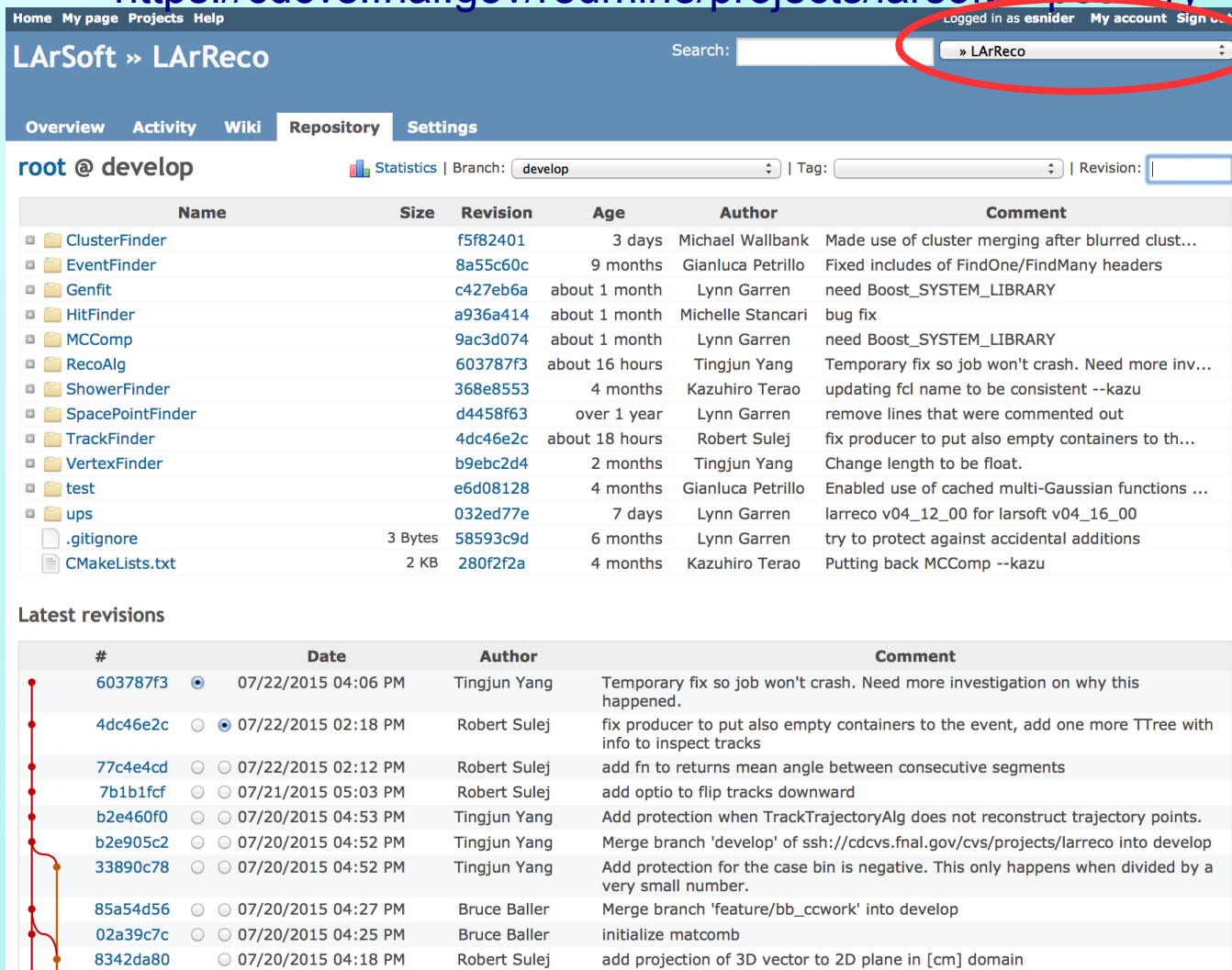
Latest revisions

#	Date	Author	Comment
603787f3	07/22/2015 04:06 PM	Tingjun Yang	Temporary fix so job won't crash. Need more investigation on why this happened.
4dc46e2c	07/22/2015 02:18 PM	Robert Sulej	fix producer to put also empty containers to the event, add one more TTree with info to inspect tracks
77c4e4cd	07/22/2015 02:12 PM	Robert Sulej	add fn to returns mean angle between consecutive segments
7b1b1fcf	07/21/2015 05:03 PM	Robert Sulej	add optio to flip tracks downward
b2e460f0	07/20/2015 04:53 PM	Tingjun Yang	Add protection when TrackTrajectoryAlg does not reconstruct trajectory points.
b2e905c2	07/20/2015 04:52 PM	Tingjun Yang	Merge branch 'develop' of ssh://cdcvcs.fnal.gov/cvs/projects/larreco into develop
33890c78	07/20/2015 04:52 PM	Tingjun Yang	Add protection for the case bin is negative. This only happens when divided by a very small number.
85a54d56	07/20/2015 04:27 PM	Bruce Baller	Merge branch 'feature/bb_ccwork' into develop
02a39c7c	07/20/2015 04:25 PM	Bruce Baller	initialize matcomb
8342da80	07/20/2015 04:18 PM	Robert Sulej	add projection of 3D vector to 2D plane in [cm] domain

Each LArSoft repository lives in a separate Redmine project which is specified here.

Navigating between LArSoft sub-projects

<https://cdcv.s.fnal.gov/redmine/projects/larsoft/repository>



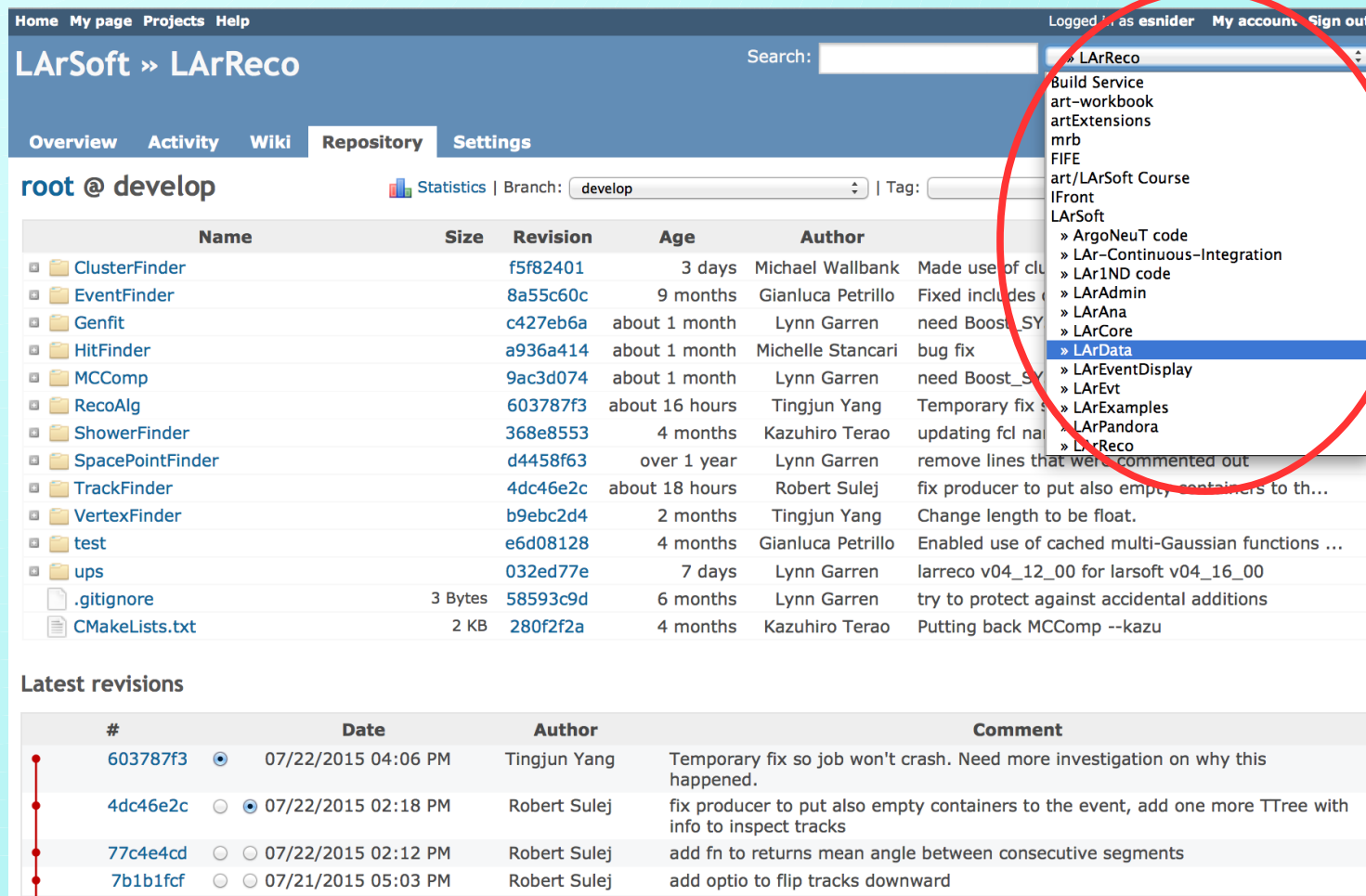
The screenshot shows the LArSoft repository page. At the top, there is a navigation bar with links for Home, My page, Projects, and Help. Below this, the page title is "LArSoft » LArReco". A search bar is present, and a pull-down menu is highlighted with a red circle and an arrow pointing to it. The pull-down menu shows "» LArReco". Below the navigation bar, there are tabs for Overview, Activity, Wiki, Repository, and Settings. The Repository tab is selected. Below the tabs, there is a section for "root @ develop" with a Statistics link, a Branch dropdown set to "develop", a Tag dropdown, and a Revision input field. Below this is a table of sub-projects with columns for Name, Size, Revision, Age, Author, and Comment. The table lists various sub-projects like ClusterFinder, EventFinder, Genfit, HitFinder, MComp, RecoAlg, ShowerFinder, SpacePointFinder, TrackFinder, VertexFinder, test, and ups. Below the table is a section for "Latest revisions" with a table showing the most recent changes, including revision numbers, dates, authors, and comments.

Name	Size	Revision	Age	Author	Comment
ClusterFinder		f5f82401	3 days	Michael Wallbank	Made use of cluster merging after blurred clust...
EventFinder		8a55c60c	9 months	Gianluca Petrillo	Fixed includes of FindOne/FindMany headers
Genfit		c427eb6a	about 1 month	Lynn Garren	need Boost_SYSTEM_LIBRARY
HitFinder		a936a414	about 1 month	Michelle Stancari	bug fix
MComp		9ac3d074	about 1 month	Lynn Garren	need Boost_SYSTEM_LIBRARY
RecoAlg		603787f3	about 16 hours	Tingjun Yang	Temporary fix so job won't crash. Need more inv...
ShowerFinder		368e8553	4 months	Kazuhiro Terao	updating fcl name to be consistent --kazu
SpacePointFinder		d4458f63	over 1 year	Lynn Garren	remove lines that were commented out
TrackFinder		4dc46e2c	about 18 hours	Robert Sulej	fix producer to put also empty containers to th...
VertexFinder		b9ebc2d4	2 months	Tingjun Yang	Change length to be float.
test		e6d08128	4 months	Gianluca Petrillo	Enabled use of cached multi-Gaussian functions ...
ups		032ed77e	7 days	Lynn Garren	larreco v04_12_00 for larsoft v04_16_00
.gitignore	3 Bytes	58593c9d	6 months	Lynn Garren	try to protect against accidental additions
CMakeLists.txt	2 KB	280f2f2a	4 months	Kazuhiro Terao	Putting back MComp --kazu

#	Date	Author	Comment
603787f3	07/22/2015 04:06 PM	Tingjun Yang	Temporary fix so job won't crash. Need more investigation on why this happened.
4dc46e2c	07/22/2015 02:18 PM	Robert Sulej	fix producer to put also empty containers to the event, add one more TTree with info to inspect tracks
77c4e4cd	07/22/2015 02:12 PM	Robert Sulej	add fn to returns mean angle between consecutive segments
7b1b1fcf	07/21/2015 05:03 PM	Robert Sulej	add optio to flip tracks downward
b2e460f0	07/20/2015 04:53 PM	Tingjun Yang	Add protection when TrackTrajectoryAlg does not reconstruct trajectory points.
b2e905c2	07/20/2015 04:52 PM	Tingjun Yang	Merge branch 'develop' of ssh://cdcv.s.fnal.gov/cvs/projects/larreco into develop
33890c78	07/20/2015 04:52 PM	Tingjun Yang	Add protection for the case bin is negative. This only happens when divided by a very small number.
85a54d56	07/20/2015 04:27 PM	Bruce Baller	Merge branch 'feature/bb_ccwork' into develop
02a39c7c	07/20/2015 04:25 PM	Bruce Baller	initialize matcomb
8342da80	07/20/2015 04:18 PM	Robert Sulej	add projection of 3D vector to 2D plane in [cm] domain

Can use the project navigation pull-down to get to the desired project.

Navigating between LArSoft sub-projects



Home My page Projects Help

LArSoft » LArReco

Search:

Overview Activity Wiki Repository Settings

root @ develop

Statistics | Branch: | Tag:

Name	Size	Revision	Age	Author	Comment
ClusterFinder		f5f82401	3 days	Michael Wallbank	Made use of clu
EventFinder		8a55c60c	9 months	Gianluca Petrillo	Fixed includes
Genfit		c427eb6a	about 1 month	Lynn Garren	need Boost_SY
HitFinder		a936a414	about 1 month	Michelle Stancari	bug fix
MCComp		9ac3d074	about 1 month	Lynn Garren	need Boost_SY
RecoAlg		603787f3	about 16 hours	Tingjun Yang	Temporary fix s
ShowerFinder		368e8553	4 months	Kazuhiro Terao	updating fcl na
SpacePointFinder		d4458f63	over 1 year	Lynn Garren	remove lines that were commented out
TrackFinder		4dc46e2c	about 18 hours	Robert Sulej	fix producer to put also empty containers to th...
VertexFinder		b9ebc2d4	2 months	Tingjun Yang	Change length to be float.
test		e6d08128	4 months	Gianluca Petrillo	Enabled use of cached multi-Gaussian functions ...
ups		032ed77e	7 days	Lynn Garren	larreco v04_12_00 for larsoft v04_16_00
.gitignore	3 Bytes	58593c9d	6 months	Lynn Garren	try to protect against accidental additions
CMakeLists.txt	2 KB	280f2f2a	4 months	Kazuhiro Terao	Putting back MCComp --kazu

Latest revisions

#	Date	Author	Comment
603787f3	07/22/2015 04:06 PM	Tingjun Yang	Temporary fix so job won't crash. Need more investigation on why this happened.
4dc46e2c	07/22/2015 02:18 PM	Robert Sulej	fix producer to put also empty containers to the event, add one more TTree with info to inspect tracks
77c4e4cd	07/22/2015 02:12 PM	Robert Sulej	add fn to returns mean angle between consecutive segments
7b1b1fcf	07/21/2015 05:03 PM	Robert Sulej	add optio to flip tracks downward

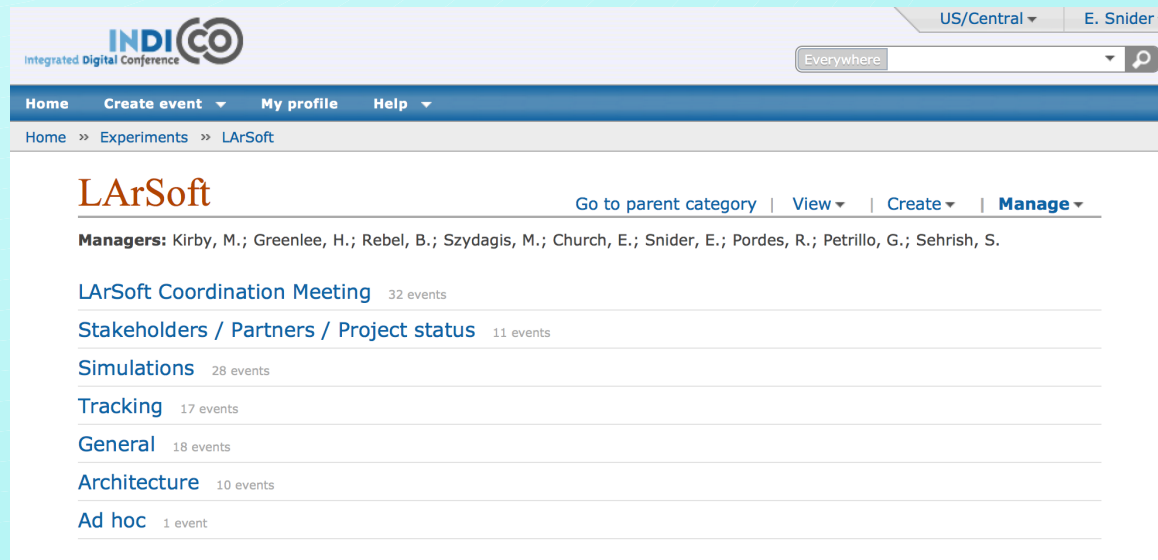
Can use the project navigation pull-down to get to the desired project.

LArSoft Indico site

- Slides and documents from meetings are posted to Indico

<https://indico.fnal.gov/categoryDisplay.py?categId=233>

- Or from the Indico home page: <https://indico.fnal.gov/index.py>, follow “Experiments”, then “LArSoft” links to arrive at the LArSoft page



The screenshot shows the LArSoft page on the Indico website. The page has a header with the Indico logo and navigation links. The main content area displays the LArSoft category with a list of events. The events are categorized as follows:

Category	Number of Events
LArSoft Coordination Meeting	32 events
Stakeholders / Partners / Project status	11 events
Simulations	28 events
Tracking	17 events
General	18 events
Architecture	10 events
Ad hoc	1 event

Can upload slides on the page for the particular meeting...

...but, must be logged in using your **Indico account** and password

Resources

- LArSoft dOxygen documentation system:
 - <http://nusoft.fnal.gov/larsoft/doxsvn/html/index.html>
- LArSoft email list: larsoft@fnal.gov
 - General announcements. Some technical questions too.
 - Can self-subscribe. See <http://listserv.fnal.gov/> for instructions.
- LAr reconstruction software forum: <http://www.larforum.org/forum>
 - Help with general problems in LAr software
- **LArSoft Coordination Meeting**
 - Bi-weekly at 09:00 Central Time in WH3NE
 - Remote connections via ReadyTalk. Slides posted to LArSoft Indico site.
- LArSoft wiki: <https://cdcv.sfnal.gov/redmine/projects/larsoft/wiki>
 - Quick page with links to quick-start guides by experiment
- LArSoft issue tracker
 - <https://cdcv.sfnal.gov/redmine/projects/larsoft/issues/new>
- 2015 LArSoft course material
 - <https://indico.fnal.gov/conferenceTimeTable.py?confId=9928#20150807>

Core LArSoft support team

- Core team members

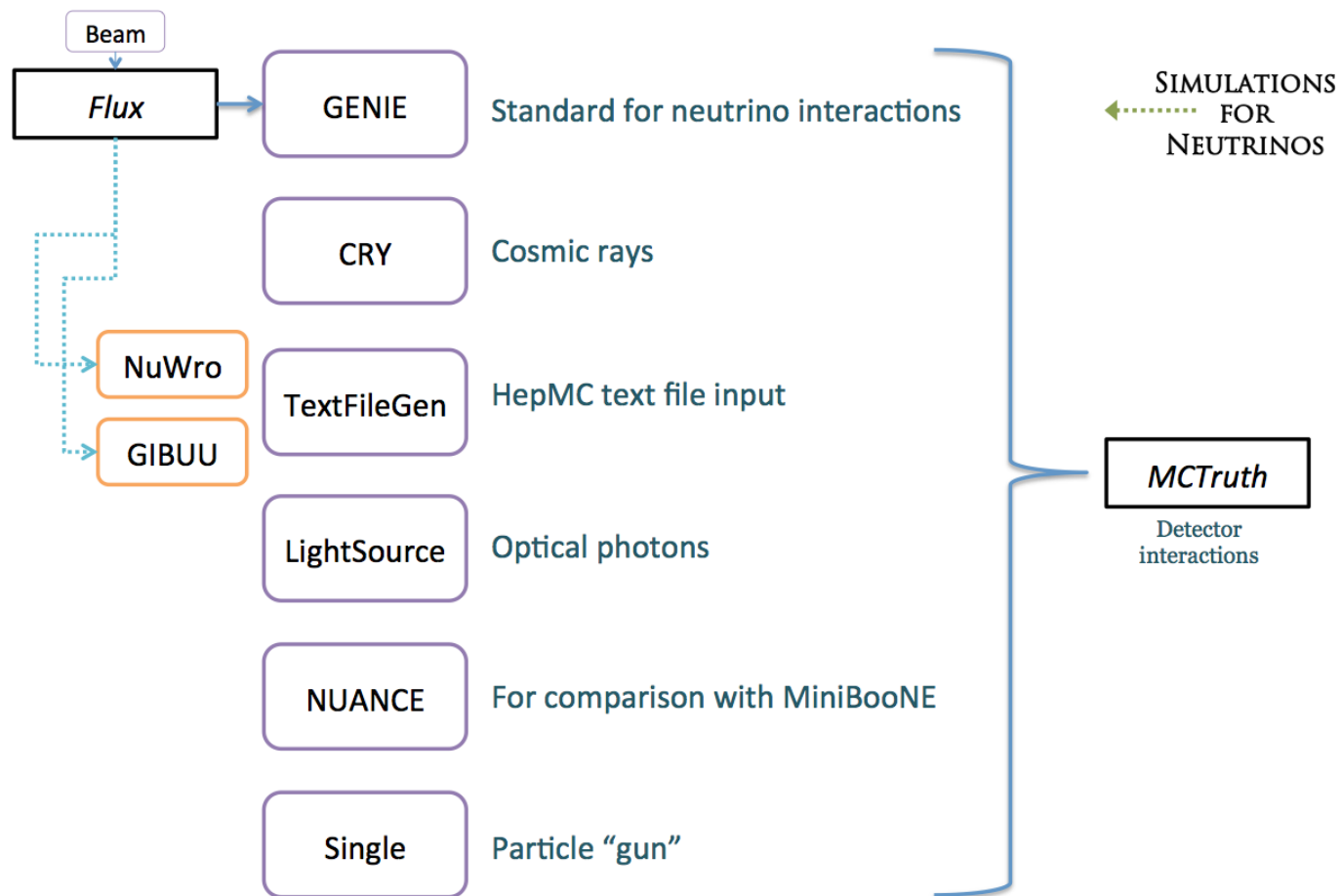
- Technical lead: Erica Snider
erica@fnal.gov
- Project manager: Ruth Pordes (soon to be Katherine Lato)
ruth@fnal.gov. klato@fnal.gov
- Lead developer: Gianluca Petrillo
petrillo@fnal.gov
- Developer: Saba Sehrish
ssehrish@fnal.gov
- Code management and distribution: Lynn Garren
garren@fnal.gov
- CI operations and testing support: Vito di Benedetto
vito@fnal.gov
- Documentation: Katherine Lato

Email / visit any of the project team!!

The end

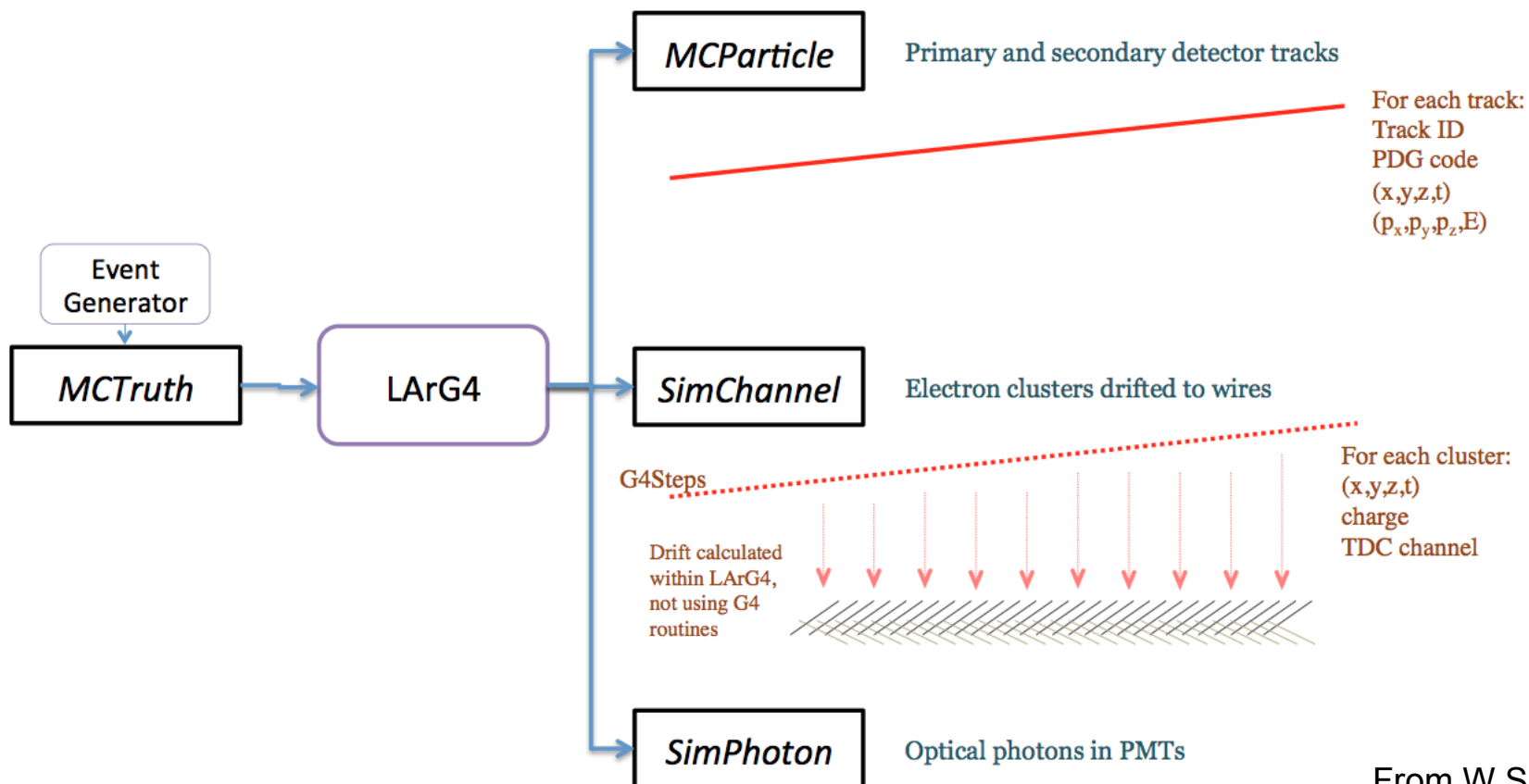
Backup

Event generators



From W Seligman

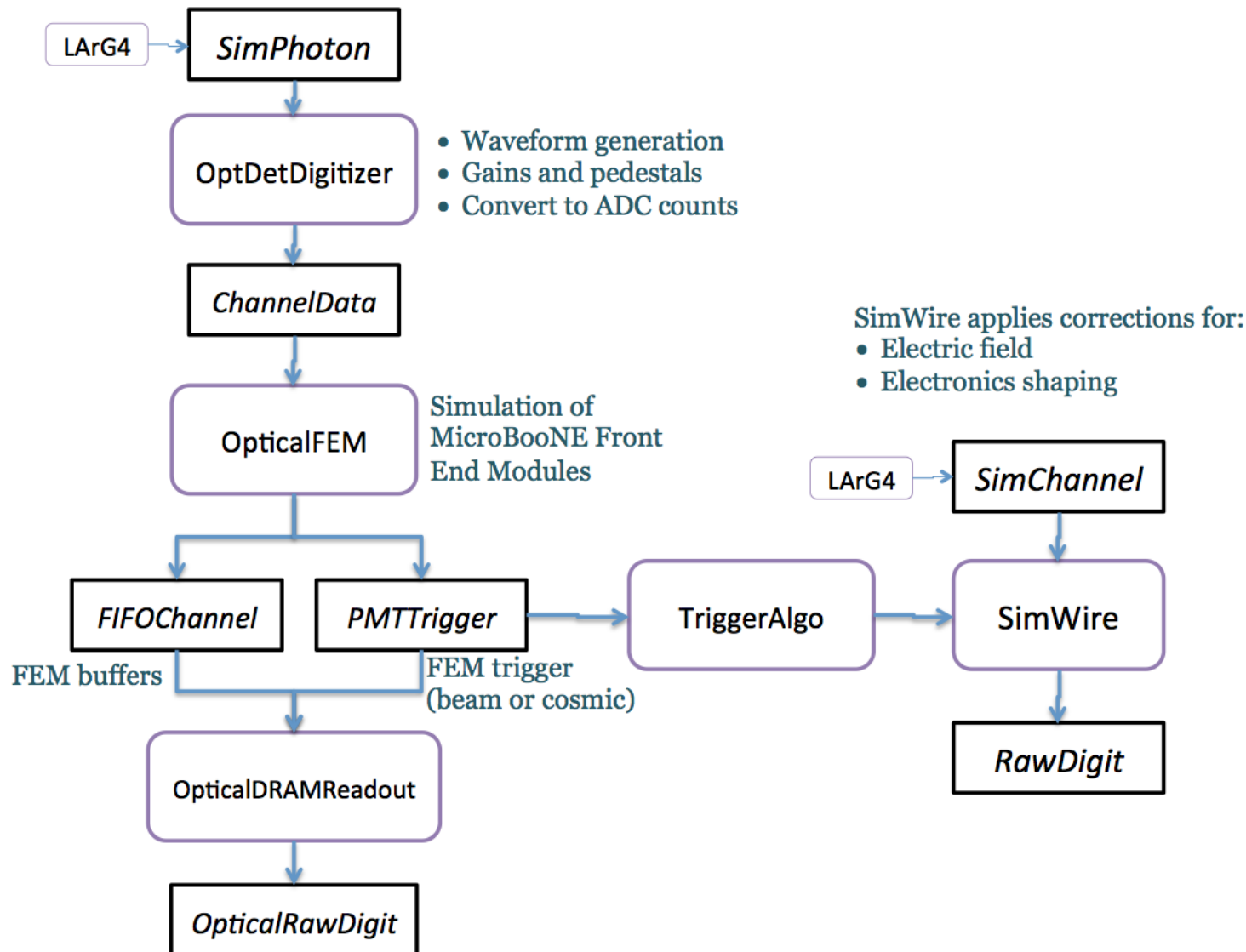
Detector simulation



From W Seligman

Simulation task workflow

Detector response and digitization



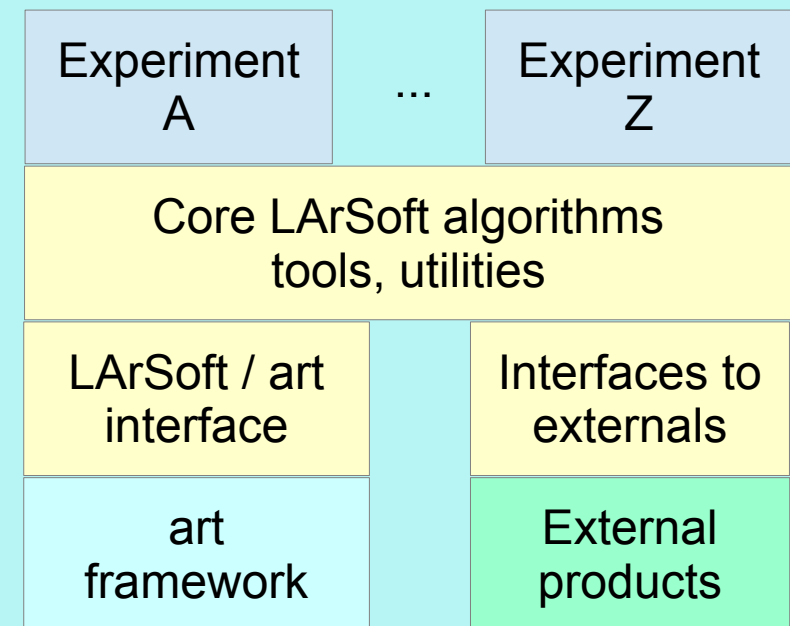
LArSoft design principles and objectives



- Detector interoperability
 - The most important design objective for the LArSoft project
 - Requires care to define (and use!!) common interfaces for accessing detector-specific configuration information
 - Good example: access to detector geometry information
 - A single interface that accommodates different (albeit very similar) geometries
 - Most differences a matter of configuration only
 - Also have detector-specific implementations of the interface where needed
 - Carefully avoid implied geometrical assumptions in algorithms
 - Position of the first plane or wire, the wire spacing, etc.
 - Introduced structures to facilitate generic loops over geometrical elements
 - Define detector / DAQ element IDs at all levels of detector geometry hierarchy
 - Can thereby avoid explicit reference to indices for loops, etc.
 - Also applies to
 - Access to calibration data, LAr properties, detector properties, E-field map, handling of common metadata for data files...
 - Have compiled a long list of do's and don'ts to ensure interoperability

LArSoft design principles and objectives

- Separation of framework and algorithm code
 - Encapsulate algorithms, configuration, tools and utilities into a layer that is independent of the framework
 - Why??
 - Allow testing of small units of algorithm code outside the framework
 - Provide greater flexibility in using algorithms
 - To provide a means of integrating LArSoft code (data products and algorithms) with external frameworks
 - e.g., LArLite used by MicroBooNE for algorithm development, testing
- See [art guidance for writing modules](#) for further discussion



LArSoft design principles and objectives

- Separation of framework and algorithm code

- Encapsulate algorithms, configuration, tools and utilities into a layer that is independent of the framework

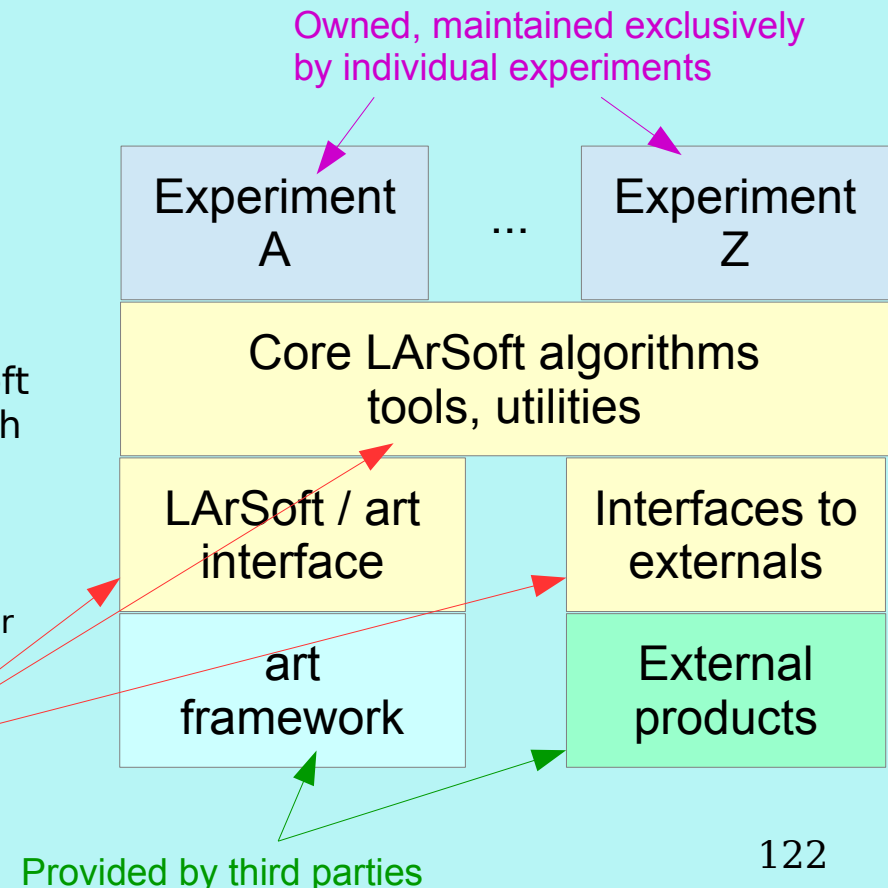
- Why??

- Allow testing of small units of algorithm code outside the framework
- Provide greater flexibility in using algorithms
- To provide a means of integrating LArSoft code (data products and algorithms) with external frameworks

- e.g., LArLite used by MicroBooNE for algorithm development, testing

See [art guidance for writing modules](#) for further discussion

All this code lives in LArSoft repositories



LArSoft design principles and objectives

- Separation of framework and algorithm code (cont'd)
 - How??
 - Adhere to particular design patterns for the “LArSoft / art interface” code
 - I.e, art modules and services (to be discussed later)
 - Access framework functionality only within the interface code
 - Includes finding input data, writing output data, retrieving any required services, making filter decision calls, etc.
 - Pass all required data, utility classes into algorithms, and all output data back out

General disclaimer: In examining the code, you may note that only a portion of the existing code adheres to this and the other design principles.

- The on-going architecture review project is intended to address this

Strongly encouraging people to adopt this practice for new code.

LArSoft design principles and objectives

- Standardized algorithm interfaces
 - Define standard interfaces for well-defined steps in the workflow so that:
 - Multiple algorithms that address specific problems can share interfaces
 - Promote greater modularity, layering of algorithms
 - Generally enhances flexibility of the code
- Modularity
 - Build sophistication by applying small, targeted algorithms in a layered, iterative structure
 - Leads to code that is more easily tested, more maintainable, more flexible

LArSoft design principles and objectives

- Continuous integration

- A development scheme in which changes to the main branch of development are integrated and tested frequently
 - At every push to the develop branch
 - Every night
 - At every release
- Primary LArSoft goals
 - Ensure that code performs as intended
 - Facilitate early detection of problems created in one experiment due to changes introduced by another experiment
 - Ensure that all major features in the develop branch work at all times
- Are now operating a continuous integration system for LArSoft
 - Currently runs at every push to develop branch
 - Can be triggered manually to run on a non-develop branch of a user's choosing



Requires that code authors write tests!

See <https://cdcvs.fnal.gov/redmine/projects/lar-ci/wiki> for details